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CURIOSITIES

OF

PHYSICAL GEOGRAPHY.

By W. WITTICH.

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NOTICE.

The greater number of natural phenomena which are met with everywhere, or at least in all zones and climates, are described and explained in that branch of natural philosophy which goes by the name of *Physics*. Others, however, are limited to certain portions of our globe. These last mentioned constitute one of the principal objects of that branch of knowledge which is called *Physical Geography*. The phenomena which more exclusively may be considered as portions of Physical Geography, are of two different descriptions. Some of them are connected with the structure of the universe, and originate in the relation existing between the sun and other heavenly bodies, and our globe. Most of them owe their origin to the difference of the effects produced by the sun's rays on different parts of the earth's surface, and these phenomena are, of course, limited to certain zones. Others, however, are the effects of localities. The origin of some of them is exclusively to be ascribed to the inequalities of the surface of our globe, *i. e.* to the peculiar situation and formation of its mountains, plains, and valleys, its continents and oceans; whilst others, as volcanoes and earthquakes, proceed from the very interior of the earth.

An account of some of the most remarkable of these phenomena is offered to the public, in this volume. The author has endeavoured to avoid all minute details, but tried to convey to the reader a complete idea—at least to a certain extent—of the most prominent characteristics of these phenomena. The reader will judge for himself how far the author has succeeded in carrying into effect this part of his plan. He has also tried to point out the effects which some of these phenomena have had in promoting the interests of the human race, and the dispersion of civilization over the surface of the globe.

The reader will find that in this collection no account is given of some of those phenomena which by their peculiar nature are more calculated than others to strike our senses, and consequently to excite our curiosity and attention in an eminent degree, and which therefore deserve a more minute description. Such are volcanoes and earthquakes. It is, however, intended to supply this deficiency in one of the following Weekly Volumes, constituting the Second Series of 'Curiosities of Physical Geography.'

CURIOSITIES

OF

PHYSICAL GEOGRAPHY.

SECTION I.—SNOW-MOUNTAINS.

THE planet we inhabit is enveloped by air, which follows its motions and revolves with it about its axis. Air must therefore be considered as an integral part of the planet, and our globe to consist of air, land, and water. When air is spoken of as a separate and distinct body, it is called atmosphere. It must not be supposed, however, that the whole space which intervenes between our planet and other celestial bodies is filled by air. If that were the case, we should never have night, but that part of the natural day which we call night would be distinguished from that which we call day only by a fainter light, resembling twilight, for twilight is but the reflection of the sun's light from the higher strata of the atmosphere; consequently, if the whole space extending from our globe to the other heavenly bodies were filled up by air, strata of air would be found over our heads, so situated as to lie beyond the shadow of our earth, and these strata would reflect the sun's light all the time the sun was under the horizon, and would change the darkness of our nights into twilight. As this does not take place, we are compelled to conclude that only the space near our earth is occupied by air, and that at some distance from it air ceases to exist.

This leads us to the question, to what distance from the surface of the earth does the atmosphere extend? We have no means to determine this point but by the duration of twilight. It is, however, very difficult to ascertain exactly the length of time which twilight lasts. We know exactly the time it begins in the evening, namely at sunset, and also when it terminates in the morning, namely at sunrise, but its termination in the evening, and its beginning in the morning, are difficult to fix to a minute, as the changes in the light are so extremely gradual that our sight has not that degree of nicety which is required to mark exactly the line which separates night from twilight. Besides, it is a known fact that the length of twilight varies at the same place according to seasons, and also that it varies at different places, when they are situated to the north or south of one another. Taking all these differences into account, it has been roughly calculated that the mean duration of twilight is about half an hour. Now it is known that in that time the sun descends fifteen degrees below the horizon; and taking these two facts as premises, it has been calculated that air which is still able to reflect the sun's light ceases to exist at a distance of about 81,000 yards, or forty-six miles, from the surface of our planet. This is therefore the extent of the atmosphere.

Each of the three substances of which our globe is composed—earth, water, and air—is possessed of some peculiar qualities. One of those by which air is distinguished, is its great elasticity, in virtue of which it may be compressed by external force, but expands again as soon as the pressure ceases. This peculiarity of the air imparts to our atmosphere a peculiar constitution. A certain space, say a cubic foot, contains a greater quantity of air near the surface of the earth than at a distance of a hundred feet from it; and the contents of air in a cubic foot at the latter place are much greater than when taken at a distance of a thousand feet from the surface, and so on. The farther we recede from the surface of the earth, the smaller is the quantity of air contained in a determined space. To this peculiar constitution of the atmosphere the terms *density* and *rarity* are applied. When a greater quantity of air is contained in a certain space, it is said that the air is more dense; and when a smaller quantity is found, it is said that it is more rare. Frequently the term denser or rarer strata is used to indicate the difference of the quantity of air contained in a determined space at different distances from the surface of the earth; but there are, properly speaking, no strata, the air becoming continually and gradually rarer as we recede from the surface of the earth. It is not difficult to account for this peculiar constitution of the atmosphere. The air is compressed by its own weight—that is to say, the air superincumbent on the surface of the earth has to sustain the pressure of the whole volume of air which lies above it, and extends to the very limits of the atmosphere, and by this weight it is compressed. At a distance of a thousand feet from the surface of the earth, it has to sustain the pressure of a column of air which is by a thousand feet shorter, and contains a more rarefied air. It therefore is compressed by a much lesser weight, and in consequence does not acquire the density which is found in the air contiguous to the surface of the earth. Thus the density of the atmosphere must decrease in proportion as we recede from the surface of the earth.

This peculiar constitution of the atmosphere greatly affects the climate of the habitable portion of the globe. The air in itself is neither warm nor cold, but it is gifted with the quality of becoming heated by the sun's rays. The degree of heat imparted by the sun's rays to the air depends partly on the length of time during which the rays act on it, and partly on the degree of its density. The heat is consequently greater where the air is denser, and less so where the air is rarer. Places which are low (that is to say, which are but little raised above the level of the sea, which is to be considered as the true surface of the globe) are much warmer than places which are some thousand feet above the sea-level. The difference increases in proportion as we ascend higher above the sea. When we thus continue to ascend, we at last come to places where the air is so rare that the degree of heat imparted to it is so small that water no longer continues in its fluid state, but is converted into ice, or, if in the form of vapour, into snow. That stratum of air where this change takes place in the atmosphere is considered as a line marked by nature itself, and called the *snow-line*. As the heat increases or decreases exactly in proportion to the increase or decrease of the density of the air, and as this density decreases regularly in receding from the earth's surface, we should expect that the snow-line would occur at the same distance from the earth's surface at every place in the globe; but this is not the case. It occurs at a much greater elevation in the torrid than in the temperate zone, and is still lower in the frigid zone. To explain this phenomenon we must call in another law of nature.

The density of the air alone does not constitute the temperature of a place. It depends as much, if not more, on the manner in which the sun's rays act on the air. The greatest degree of heat is developed where the rays pass perpendicularly through the atmosphere. A much smaller degree of heat is produced when the rays fall obliquely; and the greater this obliquity, that is to say, the smaller the angle formed by the sun's rays and the surface of the earth, the less heat is developed in the air. Those countries only which are situated between the two tropics are heated by the perpendicular rays of the sun, or are acted upon under a very great angle. Therefore a greater degree of heat is developed in the air, and their temperature is much higher. Countries lying without the tropics, but not far from them, are only acted upon by the oblique rays of the sun, and their temperature is lower. In proportion as we recede from the tropics towards the poles, the degree of heat decreases more and more until we arrive at the vicinity of the poles, where the angle under which the sun's rays act upon the atmosphere is so small as to develop a degree of heat that would be hardly sensible if the sun did not remain for several months above the horizon.

This arrangement of nature of course greatly affects the elevation of the snow-line. In hot countries it is much farther from the surface of the earth than in temperate countries, and in these farther than in cold countries. By numerous observations, it has been ascertained that in those countries which are near the equator the snow-line is found about 16,000 feet, or three miles, above the sea-level. In places which are equally distant from the equator and the poles—namely, in those near 45° of latitude—it occurs at an elevation of 9000 feet, or one mile and three quarters. Under 60° of latitude, snow is always found on mountains which rise to 5000 feet, or to less than a mile, above the sea-level; at 70° of latitude, at an elevation of 1000 feet ; and at 80° the snow-line comes down to the surface of the earth, for countries which are 10° of latitude distant from the poles are covered with snow all the year round, even when their level is only a few inches above that of the sea.

Between the snow-line and the surface of the earth is the space which is assigned to nature for its organic operations. It is here that all the plants germinate and grow, that animals find their food, and man what is requisite for his subsistence. Though man finds it too cold to settle permanently near the snow-line, he visits its vicinity during the summer with his herds. Where cattle and sheep do not find pasture, the reindeer and the yak find their favourite food. The last-named animal is little known. It lives in the most elevated part of the globe, the table-land of Pamir, which by the natives is emphatically called 'The Roof of the World.' The yak is of the ox species. It stands about three feet and a half high, and its belly reaches within six inches of the ground. Long hair streams down from its dewlap and fore-legs, and its bushy tail sweeps the ground. Other animals require the provident care of men to subsist them through the winter. The most hardy sheep would fare but badly without human protection, but the yak is entirely left to itself. It frequents the mountain slopes and their level summits. Wherever the mean annual temperature does not rise above the freezing-point is the climate for the yak. If the snow on the elevated flats lie too deep for him to crop the herbage, he rolls himself down the slopes, and eats his way up again. When arrived at the top, he rolls down again, and completes his meal as he forms another groove of snow in his second ascent. The heat of summer sends the animal to the places constantly covered with snow, and the inhabitants leave their sheltered valleys and follow their herds. The milk of the yak is richer than that of the common cow, but the quantity it yields is less. Their hair is clipped once a-year in the spring: it is strong, wiry, and pliant, and is made into ropes, which for strength do not yield to those manufactured from hemp. The hair of the body is woven into mats, and also into a fabric which makes excellent riding trowsers. Its bushy tail is the well-known *chowry* of Hindustan, where it sells very dear on account of its great beauty, and where it is used as a fan. If we add the use which is made of its flesh as food, its hide for boots and other articles of dress, and its horns for drinking-vessels, we may say that this animal, which lives on the very border of the snow-line, is able to satisfy, like the reindeer of the Laplanders, nearly all the wants of men. It is besides used for riding; and on the mountains which it inhabits is preferred to all other animals for that purpose. Wherever a man can walk, a yak may be ridden. Like the elephant, he possesses a wonderful knowledge of what will bear his weight. If travellers are at fault, one of these animals is driven before them, and it is said that he avoids the hidden depths and chasms with admirable sagacity. Should a fall of snow close the mountain passes to man and horse, a score of yaks driven a-head soon tread down the snow, and make a practicable road.

Wherever in the torrid zone a mountain-mass rises to such a height that its top is always covered with snow, a traveller may in ascending its acclivities pass in a short time through all the climates he would encounter in travelling from the equator to the moss-covered mountains of Lapland. At and near the base of the mountain his way lies through plantations of palms and plantains, through fields of sugar-cane, cotton, and other tropical productions, and through groves of the most delicious fruits. By degrees the scene changes, and when he has mounted about 8000 feet about the sea-level, he finds himself surrounded by forests of oak, beech, and other trees of the temperate zone, which are frequently interrupted by fields of wheat, barley, and other productions of our country, interspersed here and there by groves of apple, peach, apricot, fig, and orange trees. The trees with deciduous leaves are soon displaced by conifera, such as the pine, fir, larch, &c.; the fields present only barley and potatoes, and the fruit-trees have given way to bushes, such as raspberry and others. When the traveller leaves this region and approaches the snow-line to within a thousand feet and more, the bushes and fields disappear entirely, and the stones of the mountains are only clad with herbage, among which here and there single flowers are observable. But near the snow-line itself the whole mountain-mass, where its acclivities are not too steep to admit of vegetation, is overgrown with mosses.

The mountains which are always capped with snow, not producing anything useful to man or beast, would seem to be useless in the economy of nature as far as regards the maintenance of the animated creation. But such is not the case. They diffuse fertility through extensive countries, by giving rise to rivers, and by keeping them well supplied with water, which may be applied by the inhabitants, and at many places is applied, to irrigate the fields and to obtain from them richer crops than could be got by any other mode of management. This is especially the case in warm countries, where rains are periodical, and where for several months not a drop of rain falls. During these rainless seasons the soil is dried and parched by a continual evaporation, and all minor vegetation would die away were the waste of moisture not supplied by irrigation with water drawn from the rivers. It is true that mountains which do not rise to the snow-line keep up the water in the streams all the year round, but their supply is but scanty when compared with those rivers whose sources are found under eternal masses of snow. Though on the banks of the first class of rivers a considerable population may subsist on the produce of the fields, it is not commonly half as large as that which owes the supply of its wants to the bounty dispersed over their fields by the snow-born streams. In our countries, which kind Providence has blessed with an annual fall of snow and with abundant showers of rain during all seasons of the year, the advantage which hot countries derive from such rivers can hardly be understood in all their extent, and consequently has not been duly appreciated. But what immense tracts of the surface of the globe would be nothing but mere wastes were their rivers deprived of that continual supply of water, which is derived from the gradual but never ceasing melting of the snow with which the summits of their mountains are crowned!

The snow-mountains are rarely visited by travellers. except along those foot-paths which lie across mountain-passes, and serve as the shortest lines of communication between places situated on different declivities at some distance below the snow-line. Such persons are hasty pedestrians, and commonly do not pay much attention to the operations of nature. But several of those worthy persons, who wish to make themselves acquainted with all the particular phenomena of the works of God, have not hesitated to ascend the highest summits as far as possible, to explore these regions which appear to be the abode of horror and desolation. They have not been diverted from their purpose, or terrified at the dangers which surrounded them among these enormous masses of snow and ice, on the edge of perpendicular precipices, and on the brink of yawning chasms many hundred feet in depth: nor have they hastily withdrawn themselves from those unpleasant sensations to which their bodies were subjected by the exceedingly rarefied air which they respired at such a great elevation. These sensations are not experienced in the vicinity of the snow-line, but only when the elevation of the mountain is considerably above it. The most remarkable is the feeling of exhaustion. When Lieut. Wood was on the Roof of the World in Pamir, he wished to ascertain the depth of the lake Sir-i-kol, and for that purpose tried to make an opening in the ice. He found that the slightest muscular exertion was attended with exhaustion. Half a dozen strokes with an axe brought the workman to the ground; and though a few minutes' respite sufficed to restore the breath, anything like continued exertion was impossible. A run of fifty yards at full speed made the runner gasp for breath. Indeed this exercise produced a pain in the lungs and a general prostration of strength, which was not got rid of for many hours. The human voice was sensibly affected; conversation, especially if in a loud tone, could not be kept up without exhaustion, and the pulse throbbed at a frightful rate. Saussure, when on Mont Blanc, experienced the same effects, and, besides, he and his party complained of dizziness and head-ache; they lost their appetites, but were tormented by an ardent thirst, which could only be allayed momentarily by cold water. A complete indifference respecting all worldly objects pervaded their minds. When Humboldt attempted to ascend the Chimborazo, and had nearly attained its summit, he desisted on finding that drops of blood issued from under his nails and from his eye-lids.

The greatest number of snow-mountains, as far as is known, are found in the Himalaya Mountains, or those mountain-masses which lie along the north-eastern border of Hindustan, and separate the British dominions from the Chinese empire. Along this line, for a distance of several hundred miles, masses of rocks occur from thirty to forty miles in width, which rise to from 18,000 to 25,000 or 26,000 feet above the sea-level, and from 6000 to 14,000 feet above the snow-line. The depressions by which those masses are divided from each other hardly at any place sink to 15,000 feet above the sea-level, or to 3000 feet above the snow-line. Through these depressions lie the mountain-passes, by which the communication between the two countries extending on their sides is carried on. These passes are only practicable during two or three months of the year, and even then the cold experienced is so great that horses, mules, and other animals of burden cannot endure it. Sheep alone are by nature so well protected against the effects of frost that they are not materially affected by the intense cold of this region, and for that reason these weak animals have been converted into beasts of burden. Rice and a few other articles are conveyed on their backs from the plains of the Ganges to the table-land of Thibet.

The best known snow mountains in Europe are those of the Alps. The number of the rocky masses rising above the snow-line amounts to some hundreds. At a few places they are so closely connected as to constitute a snow-mass covering a great extent of country. In the Alps of Berne, between the upper courses of the rivers Rhone and Aar, an extent of country of about six hundred square miles, or twice the area of the county of Middlesex, is one sheet of snow, with the exception of three or four narrow valleys, which run into the mass, and are so depressed as to be free from snow for several months of the year. The valleys cut in these mountains communicate with one another by foot-paths, which run for several miles over the snow, but are only practicable for a few weeks in the year, and then only for pedestrians. The snow-fields of the Alps hardly ever present level spaces on their tops of any great extent, as the snow is there lodged on declivities, which are frequently broken by short but steep ascents and descents. This imparts to their scenery a certain variety, which is greatly enhanced, and converted into a most majestic and impressive view, by the great number of rocky masses with which, in the forms of needles, steeples, ruined castles, and narrow ridges, their surface is overspread. As these rocks in most cases rise perpendicularly, or nearly so, their sides are too steep to permit snow to lodge on them, and their black colour contrasts in a most striking manner with the whiteness of the snow. Thus these snow-fields constitute one of the most attractive beauties in the scenery of the Alps.

But all snow-mountains do not present such scenery. There are in other countries extensive plains of nearly a level surface, which are raised above the snow line, and consequently always buried under snow. Such plains are found in Norway. Though these snow-plains are destitute of that majestic beauty which imparts to the snow-mountains such a degree of attraction, they are still interesting, as they show us the true nature of snow mountains, without the association of those impressions which are the effect of accidental circumstances. The best known of the snow-plains of Norway is that of Folge Fonden. It is not quite destitute of occasional beauties, but those are only found along its edges, which are surrounded on three sides by firths, or deep and narrow inlets of the sea, affording a great variety of views on the steep acclivity of the mountain-mass, over whose upper surface the snow-plain extends. Folge Fonden is a peninsula, which in its greatest length, from south by west to north by east, extends more than thirty miles, and in its width varies between twenty and eight miles. On the south-east it is connected with the mainland. The rocky masses of which this tract is composed rise on all sides with a steep acclivity to an elevation of more than 5000 feet, and their upper surface is a level plain covered with snow. When seen from below, it appears that the snow-mass is about twelve yards deep. That which lies uppermost, and which is the produce of the snow-falls of the last winter, is quite white, and forms a well-marked thin stratum, whilst the remainder appears to constitute one compact mass, whose white colour is slightly tinged with blue. Near the edges of the snow its surface is gently inclined, rising gradually towards the centre; and only at a few places, where the edge is broken by ravines, is the declivity more rapid. The inclination of the surface decreases in proportion as we advance towards the interior, and near the centre it frequently presents a dead level, across which a few low eminences extend in the form of large waves with a very gentle ascent. The snow itself appears as a conglomerate of small transparent grains of ice, resembling in form and size very minute shot, which probably at some distance under the surface are united into one mass of ice by the pressure of the superincumbent snow-masses. The surface of the snow is quite smooth, and when visited in summer, after the sun's rays have made a faint impression by dissolving the outside of the grains to a small degree, it is covered by a very thin layer of ice, as if it had been glazed, whilst on the inclined portion some slight furrows are observed which have been formed by the small quantity of water produced by slight thaws. When a stick is pushed into the snow, the resistance which is experienced continues to increase, so that at a small depth it becomes impossible to force the stick farther down.

What a different scene is presented by the snow fields of the Alps! These are the produce of enormous snow masses, which have accumulated on steep and irregular slopes. The continuity of their surfaces is broken at numerous places, and there the snow-masses, resembling ice in texture, rise like walls, crowned here and there by boldly ascending pyramids, or by groups resembling broken down buildings of ancient date. This majestic confusion receives a peculiar charm from the bluish colour, with which the ruptures of the icy masses are tinged. At many places the masses are furrowed by clefts several feet wide, which descend to a depth of a hundred feet and more. These clefts are numerous, where the snow masses, in descending over a very steep slope, or into a deep ravine, have been fractured by their own weight; and they are still more numerous where an unwieldy mass, hemmed in between two mountains, in protruding downward to form a glacier has not found a space large enough to preserve its width, and thus has been broken along its edges by the resistance offered by the rocks on its sides, or by the rapid declivity of the valley into which it descends.

The snow of these high regions consists, as already stated, of small round balls, resembling in size and form small shot of a diminutive kind. This at once shows that this snow is very different from that of the lower countries, where the snow falls in flakes. This difference is also proved by the fact, that it is impossible to press it together so as to make a snow-ball. The German peasants in Switzerland have well observed this difference, and express it in their language, calling the mountain snow *firn*, in contradistinction to *snow*. As no snow-ball can be made of this kind of snow, it is evident that none of the snow avalanches can originate on the snow-fields, though that opinion has been maintained up to very recent times. At and near the surface of the snow-fields the snow particles are disunited, and do not adhere to one another, but at some depth it is found that they change in some degree their form, becoming more flattened. In this form they approach closer to one another, and being pressed by the superincumbent stratum, they by degrees unite into one mass, which has a resemblance to the ice of which the glaciers are composed. When the mountain-mass on which the snow rests is not much raised above the snow-line, this change in its form begins to take place at a depth of a few feet below the surface, but where the mountains rise to twelve thousand feet, or four thousand feet above that line, the snow preserves its granular form to a great depth, so that only the lower stratum assumes the appearance of ice.

The difference between the snow of the lower countries and that of these elevated regions shows that they must be formed under different circumstances. It is easy to comprehend that only a small mass of aqueous vapour can ascend into the rarefied air which rises above the summits of the snow-mountains. Rain of course does not fall, as all vapours rising to that elevation are converted into snow. The summits of the mountains are, besides, above the region in which rain is generated. Heavy rain-clouds are only seen to hover over those declivities of the mountains which are overgrown with large trees. The region of the forests extends in the Alps from 3000 to 6000 feet above the sea-level, and in this region rain in summer and snow in winter are very abundant. Where the trees disappear, and are replaced by bushes, the quantity of rain decreases gradually, and goes on decreasing in approaching the snow-line. Above this line only snow falls, not in the form of flakes, but in that of very minute globules. The quantity of snow which falls in spring and autumn is not great; in winter it is still smaller, and in summer snow does not fall at all. It appears, therefore, that the whole annual quantity of snow in that elevated region is but small, which is a wise arrangement of Providence, as otherwise the snow would accumulate to an immense extent, and to such a height, that it would be impossible to pass the mountains. For these masses do not experience any diminution, except by evaporation, and it is evident that in such a rarefied air, and in such a cold climate, evaporation cannot but be very small.

Section II.—Glaciers.

The term glacier is frequently considered as being synonimous with that of snow-mountain, and both terms are sometimes used without discrimination; but they indicate very different objects, as the reader will convince himself by comparing the following account of the glaciers with the preceding one of the snow-mountains.

Glaciers are appendages to snow-mountains. There is no glacier and there can be no glacier without a snow-mountain. The glaciers are offsets of the snow-mountains. They may be compared with the branches of a tree, which extend to a considerable distance from the trunk. The snow-line itself constitutes the point where the snow-mountain terminates and the glacier begins. An extensive snow-mountain may send off a great number of glaciers. The number of glaciers which emanate from the snow-fields covering Mont Blanc amount to seventeen or eighteen, and the number is still greater of those which originate in the immense snow-masses which divide the upper course of the river Rhone from that of the Aar.

If we suppose that a mountain, whose summit is crowned by an extensive and deep mass of snow, descends on all sides with a gentle slope, we should find that the outer edge of the snow was girded by a broad band of ice all round. The cold emanating from the snow would chill the adjacent air to a certain distance from the edges of the mass, and so far the ice would extend. As this border lies below the snow-line, the alternation of cold and warmth to which it is exposed would convert the snow into ice of such a description as is found in the glaciers. We might, therefore, expect to find that all the edges of snow-mountains are surrounded by glaciers, and so they are in reality, but the greater number of them are so small as not to excite observation. The extent of a glacier depends almost entirely on the conformation of the declivities of the mountain on which the snowy mass rests. When such a mountain descends with a perpendicular or very steep declivity to a considerable depth below the snow-line, its edges terminate so abruptly as to leave no space for the formation of a glacier, except perhaps a very narrow border, which can hardly be distinguished from the snow which lies higher up. An instance of this kind is seen in the Folge Fonden, in Norway. Along its northern and western edges only a few depressions occur, in which glaciers of several hundred yards in extent are to be met with, and at the termination of which the mountain-mass descends with great steepness. On all its other sides no traces of glaciers are found. Such a formation of the mountain-masses, though frequent in many countries, rarely occurs in the Alps. The snow-covered portion of this mountain-system is on all sides surrounded by other ridges, which are connected with it at different angles, and between which valleys of various extent are found. The smallest glaciers occur on the sides of the snow-mountains themselves. Wherever there is a ravine which begins under or on the very edge of the snow, and thence descends, a glacier is formed. But as these ravines have a very rapid descent, the glacier terminates at a short distance from the snow-mass, where the slope of the ravine becomes too great to afford a permanent lodgment for the snow which is borne down by its own weight. At other places the ravines terminate at their lower extremity in a level tract covered with grass, on which the descending snow is soon melted away. There are also a few instances where the declivity along the sides of the mountain for a considerable extent is so regular, moderate, and uniform, that the snow for some distance from the edge of the perpetual snow finds support on the slightly inclined plane, and where therefore a glacier of several hundred feet in width borders the snow-masses from which it has descended. The small extent of all the glaciers of these kinds, and their remoteness from inhabited places, would hardly have excited attention, and given rise to an investigation of their peculiar nature. But there are glaciers of great extent. They are sometimes twenty miles long, and descend so far below the snow-line, that their termination is surrounded by full grown trees, cultivated fields, and orchards. These glaciers are only to be met with in valleys which descend with a gentle slope to a great distance from the snow-mountain, and are enclosed on either side by a secondary ridge of considerable elevation, which is connected with the snow-mountain at the beginning of the glacier.

The extent of a large glacier depends partly on the size and formation of the valley, and partly on the extent of the snow-mountain of which it is a branch. The peasants in Switzerland say, a lean snow-mountain cannot produce a fat glacier. A snow-field must be indeed very large to be able to supply annually a quantity of snow sufficient to feed a glacier, which descends several hundred feet below the snow-line, and is there exposed to a great waste from evaporation and melting. On this account alone a great difference in the extent of glaciers may be expected. The glacier in Switzerland which descends to the lowest level is the famous one of the Lower Grindelwald, which is annually visited by crowds of travellers, because it descends so far, and is consequently more accessible than others. The lower extremity of this glacier is only 3409 feet above the sea-level, though the lower edge of the snow-mountain from which it emanates is 8117 feet above that line. Its neighbour, the glacier of the Upper Grindelwald, terminates at an elevation of 4260 feet; and the Great Aletsh glacier, which opens into Valais, at 4413 feet above the sea. The other glaciers which are found in the Alps do not extend so far down; but in other countries some are found which approach much nearer the level of the sea.

On the western coast of Norway, near 66° lat., is Cape Kunnen. It is partly formed by a glacier which descends quite to the water's edge, except towards the end of the summer, when it recedes a few feet. Henderson, in his travels through Iceland, makes mention of the Bridemarker Yökul, a glacier in the eastern districts of the island, which had advanced so near the sea that there was hardly space enough left for a road, and it was feared that the glacier would extend itself to the water's edge, and close up the communication between the eastern and western parts of the island. The eastern shores of Greenland are so lined with glaciers that a great portion of the cliffs which front the sea are entirely composed of ice, and rise some hundred feet above the sea. Similar cliffs of ice occur in some of the inlets with which the western coast of Patagonia is indented. It is evident that in all these countries enormous masses of snow must cover the higher parts of the mountains, when we find that these offsets extend even to the shores of the sea.

The Alps of Switzerland are famous for the number and extent of their glaciers. The declivities of all those parts which sustain large masses of ice are, as it were, striated by comparatively narrow masses of ice, which descend to the valleys between the secondary ridges like rivers between their banks. In arriving at the lower extremity of a glacier, it is found that the icy mass rises with a broken and steep ascent to a considerable elevation. The masses which lie behind this projecting promontory are also much broken, traversed in every direction by deep chasms, and overtopped by numerous isolated pieces of ice, which exhibit the most fantastic shapes. In advancing farther the glacier resembles a gently sloping icy stream from half a mile to three miles wide, presenting a surface more or less undulating, and this undulating surface is more or less broken by chasms, which at their upper opening differ in width from a few inches to many feet. These chasms sometimes extend nearly from one side of the glacier to the other. The ice of the lower part of the glacier is, in general, tinged with an exquisite blue colour, which, however, in many parts passes into a green. Near the snow-mountain the blue colour becomes fainter, until it disappears entirely. In those parts where the glacier approaches the snow-masses its surface is again more broken than in its middle portion. Along the sides of the glacier are icy walls, sometimes sixty feet high and more, on which masses of bare rocks of different size are lodged. Such walls also usually surround the lower extremity of the glacier, and frequently are found in its middle. They are called *moraines*. Sometimes large pieces of rock, supported by a column of ice, are found on the surface of the glacier. They are called *glacier-tables*.

In examining more closely the phenomena of the glaciers, the *ice* of which they are composed first claims our attention. It differs as much from that which is formed in our rivers and lakes as the snow of the snow-mountains differs from that which falls in lower regions. Whoever has paid attention to the formation of ice in a pond, or along the banks of a river, must have observed that at first crystals having the form of long and thin needles make their appearance, but after they have united into a sheet of ice no marks of crystallization are apparent. The ice of the glaciers is composed of crystals, but their form differs greatly from those which are observed at the first formation of ice in water. They are polyhedrons of the most irregular shapes, but more oblong than entire. Their size varies from less than an inch to three inches in length. They have commonly on one side, rarely on both, a small protuberance, which, however, has no determinate shape, and varies greatly in form. The surfaces of the crystals are rough, warty, and slightly furrowed. The manner in which these crystals are united into one mass is very remarkable. By the pressure they have undergone they are wedged together, and by means of the protuberances are so fixed into each other, that when exposed to a temperature capable of dissolving the whole mass, the single crystals become moveable to a certain extent, but they do not fall asunder even if the interstices have already loosened. When in this state it is still found a somewhat difficult matter to take out a single crystal, and for that purpose a force must be employed by which the crystal is generally broken. As soon, however, as one crystal is removed, the others may easily be detached, and the whole mass taken to pieces. Sometimes even, by the removal of a few crystals, the whole mass will directly fall asunder. It happens, sometimes, that large pieces of ice detach themselves from the lower extremity of a glacier, or from its outer border. These masses do not melt like common ice exposed to a high temperature, by diminishing continually. The mass keeps its size and form until the whole has been completely moistened, and the single crystals have become loosened, and then the whole mass at once falls to pieces. This singular composition gives to the whole icy mass a cellular texture, which may be distinctly observed on the surfaces of the vaults which invariably occur at the lower termination of the glacier. Neither in the interior of the mass nor on its upper surface does this cellular texture show itself—at least not distinctly, when the temperature is low, or after a cold night. But it becomes apparent if coloured acids or spirits are diffused on the mass. These fluids penetrate deeply into the ice by means of the interstices, and both the crystals and interstices may be distinctly traced. It is further remarkable that these crystals attain their greatest size at the lower extremity of the glacier, and that their size is in proportion to the mass. The larger the mass, the larger the crystals. At the lower extremity of the glacier the crystals are of equal size, or nearly so, throughout; but on examining them farther upwards, and nearer the snow-mountain, they are found to be smaller on the surface of the glacier than in the interior, and that they increase in size in proportion to the depth. On the summit of the snow-mountain itself, when the upper stratum, which consists of snow, is removed, it is found that the mass below it presents the cellular texture of the glacier, but the single crystals are of smaller size.

The surface of the ice itself is extremely uneven and rough, bearing no resemblance to the ice of our ponds and lakes, which admits of skating. This roughness is to be ascribed to the different degrees of hardness of the ice itself, and to its peculiar structure. The whole mass is composed of two kinds of ice, different in hardness and in colour. They are disposed in bands or parallel veins. Thin plates of compact transparent ice alternate with others which are less hard and semi-opaque. The former are smooth, and contain nothing but ice; but the semi-opaque plates are full of air-bubbles of various forms, which are disseminated through the pure ice, and always arranged in more or less abundance in parallel planes. This imparts to them a frothy and semi-opaque appearance. The colour of the compact ice is blue, but that of the opaque a greenish white. The harder ice is less easily thawed than the opaque ice, and therefore the surface of the latter is more depressed under the general level than that of the former, which thus forms projecting ridges, separated from each other by grooves; and where this disposition of the ice continues for many fathoms, the grooves resemble the cart-ruts of a bad road.

The upper surface of the ice is distinguished by its great dryness. This has been considered as a proof that the diminution of the mass on its surface is produced by evaporation, and not by thawing. It is indeed stated that the sun's rays, even in hot weather, hardly affect the ice of the glaciers; and in proof of this supposition the fact is adduced that but rarely even small collections of water are met with. Wherever there appear small rills of running water, their origin may be traced to the sudden melting of recently fallen snow. But this phenomenon may be accounted for in a more satisfactory way. The interstices between the single crystals have a great capacity of absorbing water, and the slow effects of the sun's rays leave them time sufficient to abstract all the water thus generated on the surface of the glacier.

But whilst the upper surface is distinguished by great dryness, the lower, which rests on the rocky bottom of the valley, is extremely wet. It is here apparently that the greatest portion of the ice is destroyed by melting. This process is the effect of the natural warmth of the earth, and does not cease even in winter. Everybody must be convinced of it who examines with attention the lower extremity of a glacier. It consists of large caverns or vaults sustained by massive columns of ice. These grottos are sometimes a hundred feet high, and from fifty to eighty feet wide, but their dimensions and shapes vary greatly. Their sides, acted on by the thawing, are smooth, so that on them the reticular texture of the glacier-ice can be seen with the greatest distinctness. Through these apertures all the water is discharged which is collected by the melting of the lower surface of the glacier. In winter the stream issuing from them is but small, but in summer it gushes out in a plenteous torrent. These streams of the glaciers are remarkable for the whitish-blue colour of their waters, which they preserve for a distance of several miles. This colour is ascribed to the numerous particles of rocky matter which the torrents bring down in a state of the greatest comminution effected by attrition.

The surface of the glacier is not continuous and level, but more or less broken. The most level part is that in the middle, where, as we have already observed, the surface appears as a gently sloping plain, traversed by a smaller or greater number of chasms, according to the season of the year. Near the termination of the glacier, as also at its commencement, the whole mass appears to have been fractured. This is easily to be accounted for, as in these parts the bottom of the valley, in which the glacier lies, usually forms a rapid slope, and at the same time uneven and rugged. Where the icy masses descend a steep declivity, or are propelled over very broken ground, their surfaces present nothing but a continual succession of irregular and frequently deep chasms, and cliffs of ice rising from twenty to a hundred feet. Where the slope of the valley exceeds thirty or forty degrees, the beds of ice break into fragments, which get displaced, upheaved, and piled together in every fantastic variety of form. Masses of ice, resembling steeples or towers, and others having the form of walls, rise with sharp points or edges to a hundred feet, representing an immense ruin converted into ice. But these icy masses are subject to continual changes. "Every moment in summer," says a modern traveller, "such steeples, walls, or columns break down partly or entirely; and when these icy masses are standing on the edge of a perpendicular or precipitous rock, they tumble down with a loud but peculiar noise, and in falling are broken up into many thousand pieces, which when viewed from afar resemble the cataract of a torrent. This is one of the most extraordinary and grandest views the traveller can enjoy in the Alps."

Chasms have been frequently mentioned. There are two kinds of them, which probably owe their origin to different causes, and are distinguished by the names of *day-chasms* and *night-chasms*—because the first are stated to be formed only in day-time, and the last only in the night. The day-chasms may be best observed in the middle and more level portion of the glacier. They frequently stretch nearly across the whole width of the glacier, from one side to the other. In width they vary from a few inches to many feet at the upper opening: there they are widest, as in descending farther downward their sides contract, until they meet at the bottom in the form of a wedge. Some of the wider ones descend to the very base of the glacier. An eye-witness and attentive observer gives the following account of the formation of a chasm:—"When I was once walking," says Hugi, "on the Glacier of the Lower Aar, at three o'clock in the afternoon, and the weather being very hot, I heard a peculiar noise. Advancing directly towards the spot whence it proceeded, I had hardly walked thirty or forty paces before I felt that the whole icy mass trembled under my feet. The trembling soon ceased, and then began again, continuing by starts. I quickly discovered the cause. The ice was splitting and forming a chasm. Before my eyes it split suddenly over a space of twenty or thirty feet in length, so rapidly that I could not keep up with it. Then it appeared to cease, or rather the rent proceeded more slowly, until the trembling returned, and the splitting proceeded at an accelerated rate. Several times I advanced to the end of the new formed rent, and laid myself down on the ice. The chasm opened under my very nose, and I experienced a considerable shock. In this way I followed the splitting of the ice for nearly a quarter of an hour, until it terminated on arriving at a *moraine*. When the chasm was forming, its opening was about an inch and a half wide. Afterwards it contracted somewhat, so that at no place was it wider than an inch. The depth I estimated at about four or five feet. I observed, at the same time, that the splitting downward still continued, but very slowly. After some days I again visited the place. I found that the opening had increased to the breadth of six inches, but did not succeed in ascertaining the depth. At a distance of about twelve feet another rent had been formed, which extended exactly parallel to the first, and was about six feet deep." These rents are only formed during hot weather, especially when the wind blows from the south-west, and rain is going to fall. With the progress of the warm season their number increases; and at its termination the face of the glacier is so changed, that it cannot be recognised by those who had seen it a few weeks before. The greatest changes occur in September. It is said that during the night the openings contract, and grow narrower; and it is further stated, as a well-ascertained fact, that in winter these chasms close entirely, which is ascribed to the expansion and increase of the crystals of ice composing the mass, by the intense cold to which these regions are subject. These chasms are considered to owe their origin to the changes of temperature produced by the succession of day and night, of summer and winter. This is probable, but we have not met with any description of the process by which they are formed that could carry conviction to our mind.

We are even less acquainted with the nature of the night-chasms. These do not frequently occur in the middle portion of the glacier, but are mostly found on its upper extremity, and on the adjacent part of the snow-mountain itself. Their form is the reverse of that of the day-chasms. They have the wider opening directed towards the base of the glacier, and terminates at its upper face, under the layer of snow which there covers the icy mass. This layer of snow falls sometimes into the chasm, but more frequently it is carried away by strong gusts of wind, which come up from the interior, and bring up an exceedingly cold air. The interior of the chasm then becomes visible, and it is found that these spacious caverns of wide dimensions are filled with piles of detached ice-blocks, tossed in chaotic heaps, whilst watery stalactitic icicles of ten or twenty feet in length hang from the roof, and give to these singular vaults all the grotesque varieties of outline which are so much admired in calcareous caverns, but which here show to a far greater advantage, in consequence of their exquisite transparency and lustre, and from being illuminated, not by a few candles, but by the magical light of a tender green which issues from the walls of the crystal chambers. (Forbes.) The herdsmen of the Alps, who in summer frequent the tracts adjacent to the snow-mountains, frequently hear at night an indistinct noise of a peculiar description, which appears to proceed from beneath the glacier. It is thought that this noise accompanies the formation of a night-chasm. Chasms of this description must be much more dangerous than day-chasms, as their upper opening is frequently covered with snow, and hardly ever perceptible. Many hunters of the chamois have been precipitated to their bottom. No explanation of the origin of these night-chasms has been offered.

A phenomenon which has much attracted the attention of scientific travellers are the *moraines,* which term may be translated by *glacier-walls:* they are walls of ice extending along the lateral margins of the glaciers, and usually surrounding also their lower terminations. Thus they surround the glacier on all sides, except where it is connected with the snowy masses from which it branches off. On the top of these walls are fragments of rock of different dimensions, and stony rubbish, which have there accumulated so as to cover the upper part entirely, and to form long dykes. In some of the larger glaciers such a glacier-wall is found in the middle of the icy mass, where it runs parallel to the walls lying along its borders. It is remarkable that near the upper extremity of the glacier these walls are hardly raised above its general surface, but that in proceeding farther down they rise higher and higher: some of them attain an elevation of sixty or eighty feet above their base. In approaching, however, the lower extremity of the glacier, they sink gradually down, so that at the termination they are nearly on a level with the surface. At some places are found the *glacier-tables:* they consist of columns of ice, rising at times to eighty feet and more, and supporting on their tops a large piece of rock, which projects on all sides over the icy column.

It is not difficult to account for the rocky masses with which these walls and tables are covered. On the snow-fields, from which the glaciers emanate, are numerous masses of rock, which in many places are quite bare of snow, in consequence of the rapidity of their slope. These masses are subject to disintegration by the alternate action of wet and frost, heat and cold. It is, therefore, easy to comprehend that, by this disintegration, large fragments of rock are frequently detached, and fall on the ice-field, where they sink into the snow until they meet the compact ice. There they remain buried until they are protruded downward to the glacier, when they appear above the surface as soon as the snow melts in the lower temperature. These rocky masses are still increased by the débris which falls from the lateral mountain ridges, by which the glacier is enclosed on both sides. These facts account well for the formation of the lateral moraines, but do not apply to those which occur in the middle of the glacier. It has, however, been observed lately that the medial moraines are only found in places where two smaller glaciers have united, in the same manner as two tributary rivers form a larger river. At the place of their union the glacier-walls—which skirted the two banks of the glacier which were nearest to one another before their confluence—unite into one moraine, which continues to descend in the middle of the larger glacier formed by their union. That these medial glacier-walls continue to extend in the middle of the larger glacier to a great distance below the point of union, may be adduced as one of the most convincing proofs that the whole mass of the glacier is continually advancing downward.

It is, however, not so easy to assign a reason, why these rocks and *débris* rest on a wall of ice, which, as observed before, is raised at many places sixty or eighty feet above the level of the glacier. Many scientific travellers have exercised their ingenuity in giving an explanation of this phenomenon. They have considered it, with reason, a matter of surprise, that a dead insect or a fallen leaf, soon after it has fallen on the glacier, is buried under the ice, whilst large and heavy rocks, even when warmed by the sun's heat, do not sink under its surface, on the contrary are raised above it, and to such a considerable elevation. The most probable explication is the following. The upper surface of the glacier loses, partly by thawing and partly by evaporation, a considerable portion of its ice, and sinks continually to a lower level. Where, however, the access of air and light is excluded from its surface by inorganic and compact bodies, the mass cannot be affected by the above-mentioned causes. In this manner the ice on which the fragments of rock are lodged remains undiminished, whilst the adjacent parts sink lower and lower. The correctness of this explanation is supported by the peculiar form of the glacier-tables, where the rocky mass on the top projects on all sides to a considerable distance, aud the column of ice which supports it grows thinner and thinner the higher the table rises above the glacier, until the column is broken down by the weight of the superincumbent rock, and precipitates it on to the surface of the ice, where, however, it is soon raised again by the effects of thawing and evaporation. The circumstance that organic bodies sink into the ice and disappear in a short time, is accounted for by the well-known quality of such bodies absorbing oxygen. They thus abstract from the ice one of those elements which are essential to its existence, and the other, the hydrogen, is dispersed by evaporation.*

Almost all travellers who have been in the Alps and have visited the glaciers, speak with rapture of their *colour*. When, however, single crystals, or even small portions of the mass, are broken off, and viewed separately, they show nothing of this colour. They are commonly white and transparent like ice, or frothy and semi-opaque. The colour appears only in the entire mass. The blue colour begins to appear gradually, and passes through all the shades from the slightest tinge to the darkest hue of the *lapis lazuli*. In some glaciers the blue has a mixture of green, which doubtless is to be ascribed to the prevalence of the frothy semi-opaque layers. In the lower parts of the chasms and clefts, where the ice of the glacier is in a state of dissolution by thawing, the blue colour is of a purity and beauty which can be admired, but not described nor imitated. Where the glacier approaches the snow-mountain the colour gets fainter, and at last passes into that of the ice of the snow-mountain, which, as above observed, is white, with a tinge of blue which is hardly perceptible.

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* In many countries of Europe, as also in England, a number of single pieces of rock are dispersed over some tracts of the country, without its being possible to trace their origin to a mountain, except to such as are very distant—sometimes several hundred miles off. Such isolated pieces of rock are called *erratic* blocks, or *boulders*. Several attempts have been made to explain the manner in which these boulders have been carried to such a distance from those rocks, of which, at some remote period, they apparently constituted a portion. Lately it has been observed, that such boulders, consisting of granite, are dispersed over the declivities of the limestone rocks of the Jura Mountains, and that they are there disposed exactly as if they were brought to these places and deposited by glaciers in the form of glacier-walls. As these boulders on the Jura Mountains are found much below the level to which at present any glacier descends, Agassiz, a Swiss-Frenchman, has conceived a theory, according to which by far the greatest part of Switzerland, at some remote period, was covered entirely with snow-masses, which, when the temperature of our globe increased, were gradually melted, and in retreating to the more elevated portion of the country, deposited these boulders at different levels on the slopes of the Jura range.

A natural phenomenon of such a peculiar character and such a magnitude as the glacier, has powerfully attracted the attention of scientific men, and several theories have been formed to explain their origin. When the phenomena attending them had been observed, but not closely investigated, an apparently simple method was adopted to explain their origin. It was thought to be due to the quantity of snow which falls in the higher and colder regions of the mountains, and is only partially thawed by the heat of summer. When the slopes of these elevated mountain-masses are rapid, the snow, being unable to rest upon it, slides down into the adjacent valleys in the form of avalanches, and to this being added what in winter-time falls directly into the valleys, an enormous quantity of snow is accumulated, which becomes compressed by its own weight. This snow is converted into ice by the rains which occasionally fall, and by the water, which results from the partial melting of the snow, percolating through the whole mass, moistening it throughout; and while in this state the cold of the succeeding winter consolidates it into a glacier. This explanation, simple as it is, cannot be admitted as founded in truth, when it is considered that but little snow falls on the snow-mountains, that no avalanches originate in these higher regions, and that few of the steeper slopes are so situated as to discharge their snowy coverings into the valleys, the greater number of them being near the crest of the whole mountain-mass. This theory, besides, does not agree with the peculiar nature of the ice, as above described, which cannot have been produced by such a process, nor with the progress which the icy mass is continually making downward.

Saussure, a native of Geneva, the first to investigate closely the glaciers and the phenomena attending them, and to apply to them the known laws of nature, was aware of this progress, and was convinced that the ice of the glaciers originated on the snow-mountain itself, from which it descended slowly to its termination.

Though the fact of this movement was for a long time considered as certain, no attempts were made at any place to ascertain its rate, until Mr. Forbes, Professor of Natural Philosophy at Edinburgh, turned his attention to the subject. By him and his friends the movement of the ice of the littoral part of the *Mer de Glace* at Montlavert, near Chamouny, was attentively observed for nearly a year, and it was found that it amounted

From June 29th to Sept. 28th . . .	to 132 feet.
„ Oct. 10th to Dec. 12th	70
„ Dec. 12th to Feb. 17th	76
„ Feb. 17th to April 4th	66
„ April 4th to June 8th	88
	432 feet.
To this Mr. Forbes adds for the time in which no observations were taken . .	51
	~~481~~ feet. 48

Thus it has been ascertained that at one point at least the annual progress of the glacier-ice amounts to nearly five hundred feet.

On this progress of the ice Saussure rested his theory of the origin of the glaciers. He maintained, that when by the natural warmth of the earth the connexion between the lower surface of the glacier and the bottom of the valley had been removed, and the ice had become slippery by the moisture collected, the whole mass was borne down by its own weight, and that thus the progress of the glacier-ice was effected by a mechanical operation. To this theory it is with reason objected, that by far the larger part of the glacier rests on a slope which is not rapid enough to allow us to suppose that such heavy and enormous masses of ice could be so carried down. Besides, the glaciers do not lie in a straight line, but follow the bends of the valleys. They frequently pass through gorges, or round projecting masses. At all such places, the ice, descending of course in a straight line, would be stopped, broken, and accumulate to an immense extent, which is not the case. On these accounts the theory of Saussure has been rejected.

In later times Charpentier and Agassiz have broached another theory. They conceive that the progress of the glacier may be considered as the effect of the freezing of the water which collects in the chasms, clefts, and smaller rents. According to their opinion, a glacier is composed of a spongy ice, which continually absorbs the water derived from the atmosphere and from the melting of the ice itself. This water penetrates into the numerous narrow rents which traverse the icy body to its lowest depth, but especially those parts of it which are contiguous to its upper surface. When this water freezes, it presses with great force on all the parts which surround it, and propels those which lie on that side where the resistance is smallest, namely, down the slope of the valley. The weight of the mass assists greatly this movement. In winter, when the whole mass is frozen throughout, the glacier-ice does not move. This theory is more ingenious than solid. It appears to be quite impossible, according to all experiments and observations, that the comparatively small quantity of water collected in the rents and lower portions of the chasms, when converted into ice, should act with such a force on its sides as to be able to put in motion masses of such a magnitude as those of the glaciers. Besides, it is not true that the ice of the glacier does not move in winter. According to the measurement taken by Professor Forbes, noticed above, it is evident that it moves nearly as quick in winter as in summer.

Professor Forbes has conceived a new theory. He considers a glacier as not consisting of a mass of solid ice, but as a compound of ice and water, more or less yielding according to its state of wetness or infiltration. It is an imperfect fluid, or a viscous body, which is urged down the slopes of a certain inclination by the mutual pressure of its parts, and he compares it to a thick mortar, or the contents of a tar-barrel poured into a sloping channel. Whoever has looked at the manner in which such a fluid moves, will have observed that the middle part of the moving body advances more rapidly than those portions which form its outer edges, which must overcome the friction caused by contact with the channel, and which therefore are retarded and cannot proceed with equal velocity. Evident signs of this kind of movement have been discovered in the glaciers by Professor Forbes. They consist of curves, which lie across the surface-ice of the glacier, and extend from one side to the other. The convexity of these curves is directed towards the lower end of the slope. In the more elevated part of the glaciers the curvature is but gentle, but it increases in proceeding farther down, and towards the lower termination it presents a very elongated form. Such curves can only be formed when an imperfectly fluid body runs down a gentle slope. The nature of the ice of which the glaciers consist is certainly in favour of this theory. The interstices between the single crystals are possessed of a great capacity of absorbing water, and conducting it to a considerable distance. When these interstices and also the air-bubbles which abound in the semi-opaque layers are completely saturated, it is very probable that the whole mass contains as much water as solid ice, and in that state it may be considered as an imperfect fluid, and moves slowly forward. But according to our knowledge of the laws of nature, we can only conceive the ice of the glacier to be found in such a state during the warm season. The progress of the glacier could, therefore, only take place during that part of the year. From the statement of Professor Forbes himself, however, we must infer that the progress of the ice is hardly retarded in winter. In less than four months, from the 12th of December to the 4th of April, it advanced 142 feet. If in four months complete it had advanced 160 feet, the progress in winter would have been as quick as in summer. In this extraordinary fact lies, in our opinion, the great difficulty, which must be removed before the theory of Professor Forbes can be considered as firmly established.

Among the inhabitants of the Alps the opinion prevails that the glaciers are continually on the increase, not in elevation, but in extent. They assert that the lower extremities of these icy masses advance farther and farther into the valleys, and on the declivities of the mountains, and they cannot overcome the apprehension that in time the ice will spread over some of their richest alpine pastures, and perhaps cover them entirely. It cannot be denied that there are many instances transmitted by tradition, and even a few recorded by history, which appear to prove that this fear is not quite without foundation. Some mountain-passes and elevated valleys, which formerly were free of ice, are at present filled up; but all scientific men who have paid close attention to this subject, who have collected all the certain information regarding this supposed increase, and investigated the matter in all its bearings, are opposed to the opinion. They account for the isolated instances of the increase of the glaciers by observing that, in some winters, the quantity of snow which falls is larger than usual, and that when such a winter is succeeded by a summer in which the temperature does not rise to its usual height, the whole quantity of snow which has fallen in the colder regions cannot be dissolved. This may sometimes continue for several years in succession. In such a case it is very probable that the whole mass of the glacier increases to a certain extent, and advances farther into the valley than it did before. It may even happen that, under such circumstances, new glaciers of small extent are formed; but on the other hand it is also certain that, after some years, the reverse takes place. A smaller quantity of snow falls in winter, the mean temperature is higher, the winters are less cold, and then the new glaciers disappear, and the old ones recede within their ancient limits. According to another opinion, which however is less prevalent, the increase and decrease of the glaciers is subject to certain fixed periods. It is maintained that each of them occupies the space of seven years. Saussure, however, rejects this statement, and treats it as a fancy. According to his opinion, in this as in many other instances, nature operates with a certain degree of irregularity, which however does not materially affect the general order established by Providence in the universe.

There are perhaps no objects in nature which recompense the traveller more amply for the trouble of visiting than the glaciers, by their numerous and various beauties. These beauties are partly derived from their peculiar nature, and partly from the contrast they exhibit with the countries contiguous to their lower extremities. The immense extent of the huge icy masses, traversed in every direction by numerous yawning chasms descending to an unknown depth, and surrounded by turrets and perpendicular walls and cliffs of ice of the most fantastic forms, having in the background black rocks of an immense elevation, which rise in the shape of peaks out of a sea of extremely white snow, would fill the mind of the looker-on with horror were it not converted into astonishment and admiration by the peculiar bluish colour which spreads over the whole region up to the very borders of the snow-mountains, and attains in the chasms the deepest hue and greatest beauty. When the traveller turns his back, he finds the icy masses on which he is standing surrounded by forests, fields, pastures, and orchards. To his left is a meadow of the most verdant turf, on which flocks of sheep are feeding, attended by a shepherd who tunes his flute or sings his pastoral lay. To the right is a gentle slope entirely covered with ripe barley, in which the reapers are busy collecting the bounteous gifts of Providence; whilst before him, on the banks of a river pouring down its whitish-green waters, stands a village of neatly-constructed houses, the abodes of happiness and content, surrounded by orchards in which cherries are found in abundance. At no great distance are a few groves of high forest-trees, mostly of the pine kind, which by their sombre aspect do not fail to impress a degree of earnestness on the cheerful landscape. At many places the scenery receives an additional zest by a small lake enclosed by meadows, from whose smooth surface the surrounding mountains are reflected, with their glaciers, snow-fields, and dark peaks. At another spot a cataract precipitates its silvery waters down the perpendicular declivities of a black rocky mass, the falling stream being frequently deflected from its straight line by a gust of wind.

None of the numerous glaciers of the Alps are better known than those of Grindelwald. They are annually visited by many thousand travellers, partly because they are more accessible than the others, and partly because they may be considered as fair specimens of the glaciers. They are two in number, and situated in the valley of Grindelwald, which lies in the high mountain-masses extending between the cantons of Berne and Valais. This valley extends from north-west to south-east, and on both sides the higher part of the mountains rises above the snow-line. In the north-eastern chain is Mount Faulhorn, which rises to 8547 feet above the sea-level. The south-western chain is much more elevated, being overtopped by Mount Wetterhorn, 12,177 feet high; Mount Eigher, nearly 13,000 feet high; and the summits of Schreckhorn and Wisherhorn, which are still more elevated. The valley is at the village only 3357 feet above the sea, and therefore well inhabited. In and near it are numerous orchards of cherry-trees, well-cultivated fields, and large pasture-grounds. The two glaciers are situated at its upper end. The lower is smaller, and lies between Mount Eigher and the Mettenberg; the larger between the last-named mountain and the Wetterhorn. They lie parallel to each other. The lower one is the more beautiful, as it descends over a much more broken surface, and consequently presents a much greater variety in the icy masses with which its surface is studded. To the south and east of the Valley of Grindelwald is a mountainous country of the extent of the county of Middlesex, if not larger, which may be considered as one large glacier (for the numerous glaciers which occur in this tract are separated from one another only by ridges of snow-capped mountains), on whose back are placed a great number of high peaks, among which Mount Finsteraarhorn is the highest. It rises to 14,100 feet above the sea. Nearly as numerous are the glaciers which descend from the western base of Mont Blanc, south-east of Geneva. They lie so close together that they appear to constitute one immense mass of ice, to which the name of Mer de Glace, or Sea of Ice, is not improperly applied.

SECTION III.—AVALANCHES.

AVALANCHES are masses of snow or ice which fall from the upper declivities of high mountains into the valleys at their base, often occasioning damage, and destroying life and property. They are very frequent in the Alps, but occur also in the Pyrenees, Norway, and in all countries in which mountains rise to a great elevation. Some of them originate in those parts of the acclivities which are contiguous to the snow-line, but others at a much less elevation. When the accumulation of snow on the declivities becomes so great that the inclined plane on which the mass rests cannot any longer support it, it is carried down the slope by its own weight, and precipitated into the subjacent valley, destroying forests and villages, burying men and cattle, and sometimes filling up the rivers and stopping their courses. Besides what is actually covered by these falling masses, persons are often killed and houses overthrown by the sudden compression of the air caused by the incredible velocity with which some of the avalanches descend.

If we examine the manner in which these dangerous and terrible phenomena originate, we may distinguish four kinds of avalanches: drift avalanches, sliding avalanches, creeping avalanches, and ice or glacier avalanches.

The *drift avalanches* are composed of loose snow; they can only originate when the quantity of snow is very large, and has been lodged on a steep declivity, whence it is dislodged for want of support. The mass in falling loses its coherence, on account of the imperfect manner in which its particles have been united, or by striking violently against projecting rocks. These avalanches commonly take place in winter, when a very heavy fall of snow has occurred in the higher regions during a calm. Great masses are then lodged on declivities, which are sufficient to afford a support to them during calm weather, but not when the atmosphere is agitated by strong gusts of wind. Such winds, which are not rare at that season, detach the uppermost mass from the declivity of the mountain, and bring it down on other masses which lie lower, which in their turn are forced off, and thus an enormous volume of snow is collected before it reaches the valley. For a long time it was the prevailing opinion that they owed their origin to small balls of snow, which were formed near the upper edge of the most elevated snow-mass, and which in rolling down the declivities were increased to such an enormous size as to produce by the violence of their fall the most extraordinary effects. This opinion arose from the vulgar, but generally diffused idea, that a loud sound, or the tinkling of a bell, was able to bring down the enormous masses of snow which cover the upper regions of the mountains. As these avalanches always descend quite unexpectedly and without any apparent cause—the gust of wind not being perceived in the deep valleys—people were unable to assign any sufficient reason for their formation.* This opinion of the origin of these avalanches prevails not only in the Alps but also in the Himalaya mountains, and in the Hindu-coosh. On a closer examination, however, it has been found that strong gusts of wind originally impart the first impulse to these masses of snow, and that they acquire their size by uniting with other masses lying lower down. The incredible velocity with which they descend, and the immense force with which they strike, prove that the drift avalanches must originate at a great elevation. They are very much dreaded, not so much on account of the damage caused by the snow itself, as from the effects of the compression of the air, with which they are always attended. The air compressed by these masses rushes off on all sides with the greatest velocity, and with a force able to break off huge pieces of rock, to uproot the largest trees, and to scatter houses like chaff. It is very fortunate that the drift avalanches are of rare occurrence, and that they rarely descend to those valleys which are thickly peopled and well wooded.

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* They thought that they must be produced by a very trifling motion, and therefore adopted the above-mentioned idea of a moving ball, occasioned by the alighting of a bird, or the sound of a bell.

The *sliding* avalanches, though less destructive in their effects than the drift avalanches, cause greater damage than the others, on account of their frequency. They take place when the snowy covering of the declivities, by having been slightly thawed and again frozen, has acquired a considerable degree of consistency on its surface, and has been cemented to some extent into one mass. When under such circumstances, by the natural heat of the earth, the bond has been loosened which unites the mass to its base, and the ground on which it rests has been rendered slippery, the whole mass begins to slide downwards in one sheet, and precipitates itself over every obstacle into the valleys. These avalanches originate in the middle regions of the mountains, on declivities which have not a very rapid slope, and in spring time. They are less dangerous because they are not attended by a compression of the air, but they cause great damages by the enormous masses of snow which they bring down. These masses are sometimes so great as to cover large extents of meadow and forest with such a thick layer, that several summers must pass before they are entirely melted; this affects the climate of the valley in a very disadvantageous way. But they also frequently cause considerable loss of life and property. In the year 1749 the whole village of Bueras, in the valley of Tawich, in the canton of the Grisons, was buried under, and at the same time removed from its site by, an avalanche of this description. But this change, which happened in night-time, was effected without the least noise, so that the inhabitants were not aware of it, and on awakening in the morning could not conceive why it did not grow day. One hundred persons were dug out of the snow, sixty of whom were still alive, the hollows within the snow containing sufficient air to support life. In 1806 an avalanche descended into Val Calanca, likewise in the canton of the Grisons, transported a forest from one side of the valley to the other, and planted a fir-tree on the roof of the parsonage-house. Several villages have been destroyed by these avalanches, and a large number of persons and cattle have been killed. But in general they do not come on unexpectedly. The places where they frequently occur are known, as also what kind of weather commonly precedes their descent. The Austrian government, some years ago, wishing to connect the province of Sondrio with Tyrol, by a mountain road which was not to pass over any portion of Switzerland, but to lie entirely within their own dominions, caused a road to be made over Mount Stelvio through a region frequently exposed to sliding avalanches. Notwithstanding the extreme care with which the galleries were constructed, which were to protect the road and the passengers against them, the snow descended in such enormous masses as to break down all the galleries, and compelled the Austrian government to give up the plan. This is the only kind of avalanche which occurs in Norway, the shape of the mountain-masses in that country not being favourable to the formation of the other kinds. But as nearly all the mountain-masses have along their borders gentle declivities of considerable width, they are frequent and destructive in that country. A few years ago a number of reindeer, exceeding fifty, were found dead in a narrow and uninhabited valley, within a narrow space, which according to all appearances had been buried by an avalanche.

The *creeping* avalanches are called in Switzerland *suoggi* (pron. suggy), from a verb suogger, which signifies to advance slowly, to creep. They originate in the same manner as the sliding avalanches, but on declivities which have a much more gentle slope. The snowy covering when loosened from its rocky base begins to move slowly down the slippery declivity, and to carry before it everything which is too weak to withstand its pressure. When an object does not directly give way to its mass, it is either borne down by the snow accumulating behind it, or the whole mass divides, and proceeds in its course on each side of it. These avalanches are very frequent, but rarely cause any considerable damage, from the comparatively small volume of snow they bring down, and their slow advance. They occur mostly in spring, and on the lower acclivities of the mountains.

The *glacier* or *ice avalanches* are nothing but large fragments of glaciers, and their origin is especially due to the fracturing of the icy masses, when they are protruded downwards. They are frequently broken into small pieces by other masses of ice, or by rocks which they meet in their progress. When in such a state and seen from a distance, they resemble the cataracts of a powerful stream. In summer, which appears to be the only season in which they occur, they may every day be seen on almost all the glaciers of Switzerland, and at the base of Mount Jungfrau, in the valley of Lauterbrun, in the canton of Berne, the thunder which accompanies their fall is almost continually heard. They are not in general destructive, because they descend upon places which are not inhabited. Yet occasionally their fall is attended with terrible effects. This is especially the case when a glacier terminates on the very edge of a high mountain-mass, which descends with a perpendicular declivity into an inhabited valley. A very dreadful catastrophe of this kind occurred in 1819 in the valley of Visp in Valais, where the village of Randa was destroyed by a glacier avalanche. This village was built not far from the base of a mountain-mass, which rises nearly perpendicularly to an elevation of more than nine thousand feet above its base, and forms part of the snow mountain called Weisshorn (white horn), which is everywhere surrounded with huge masses of glaciers. One of these glaciers had advanced to the very edge of the precipice, and was overhanging it, when at once an enormous piece of it was detached, and with a terrible crash precipitated down into the valley, where it covered with ice, rubbish, and fragments of rock an area of two thousand four hundred feet in length, and a thousand feet in width, to a depth of more than a hundred and fifty feet. This mass fell on an uninhabited tract, but in its vicinity was the above-named village, which was destroyed by the compression of the air produced by the fall of that enormous mass. The force of the gust caused by this compression was so great, that it raised millstones from the ground and lodged them on a slope which was several yards above the place where they had been deposited. It conveyed the beams of several houses to a distance of nearly a mile into a forest, and broke down the steeple of the church, which was a massive building of stone.

The year previous to this event a catastrophe of a different description was produced by glacier avalanches in another valley of Valais, the vale of Bagnes. The upper basin of this valley, which is drained by a river called the Drance, is uninhabited on account of its cold climate, being much elevated and besides surrounded by glaciers. This basin is divided from the lower and inhabited part of the valley by a narrow gorge; on one side of the gorge stands Mount Mauvoisin, which terminates at a short distance from the Drance in a nearly perpendicular rock about five hundred feet high, and whose upper part is occupied by a glacier called Getroz. On the opposite bank of the river stands another high rocky mass. The gorge formed by the two mountains is not quite half a mile wide. In 1811, the masses of ice and the avalanches falling down from the glacier were so numerous and large, that the summer heat did not dissolve them. They accumulated and formed a glacier in the gorge itself. This glacier went on increasing up to 1817, when it extended over the bed of the rivulet—for such only the Drance is at this spot—and stopped its course. The consequence was that a lake began to collect behind the ice barrier, which soon attained a depth of fifty feet. But no danger was apprehended when it was discovered that the water of the lake was discharged by an opening under the glacier. This opening was unfortunately shut up by an avalanche from the Getroz glacier in 1818. The lake behind the ice barrier soon increased to eight thousand feet in length and two hundred feet in depth. The ice barrier itself which prevented the water of the lake from running off, was five hundred feet long, about one thousand feet broad, and where lowest upwards of two hundred and twenty feet above the surface of the lake. The waters, however, receiving continually a large supply from the melting snow of the very extensive Chermontane glacier, increased rapidly, and from the 14th to the 24th of May the surface of the lake rose nearly twenty-three feet. The inhabitants of the lower valley, who for some time previously had begun to pay attention to what was going on, became now alarmed, considering the dangers to which they would be exposed, if the ice barrier should give way to the pressure of the water behind. They recollected that in 1545 a similar event had laid waste the whole valley and drowned the village of Bagnes with one hundred and forty persons. They accordingly applied to the government for assistance, and suitable measures were directly taken to prevent such a misfortune. A horizontal gallery was cut through the ice barrier, six hundred feet long and fifty feet above the surface of the lake. It was thought that this elevation above the water was sufficient to allow time to finish the work before the lake could attain this height. When finished it was supposed that the new supplies of water would be carried off by this gallery, and that afterwards the water itself would dissolve the ice over which it ran, and by thus gradually deepening the cut, would also lower the surface of the lake. The operation was difficult and doubtful in its effect, but as the danger was certain and imminent, the work was pursued with great activity. The cut was finished on the 13th of June; no sooner was it terminated than the water which in the mean time had risen to the level of the cut, began to flow off through the opening, and all danger seemed to be averted. On the 16th of the month the water of the lake had already sunk forty feet, and the cut had been considerably deepened by its rush. But on the same day the water opened another road near the declivity of Mount Mauvoisin, at a place where the glacier rested on some loose pieces of rock, which not being able to withstand the pressure of the water, suddenly gave way. An enormous volume of water rushed at once into the valley; it amounted according to the public account to five hundred and thirty thousand cubic fathoms. In less than half an hour it had overwhelmed the village of Bagnes, and in a shorter period it proceeded from Bagnes to Martigny. It reached the Lake of Geneva, which is about sixty miles distant from Mount Mauvoisin, in five hours and a half. It was a happy circumstance, that the water of the Rhone was uncommonly low, so that the bed of this river was capable of containing the whole of the water, and carrying it into the Lake of Geneva; otherwise the inundation of the lower vale of the Rhone would have considerably increased the loss of property. Although signals were immediately made to acquaint the inhabitants with this event, yet about fifty persons lost their lives. Not only houses and barns were carried away, but even extensive forests, and at some places the soil lying upon the rocks was entirely washed off, so that nothing remained but the bare stone. The damage was very great, and estimated at upwards of 40,000*l.* It is however supposed that it would have been much greater if the cut had not been made through the ice barrier; for in that case the volume of water which would have collected behind it would have been twice or thrice as large, and the damage caused by it in proportion.

SECTION IV.—MOUNTAIN-SLIPS.

EFFECTS even more disastrous than those of the avalanches are sometimes produced by mountain-slips. Persons who have passed some time in the Alps know very well that frequently smaller fragments of rocks roll down the sides of a steep acclivity, so that those who are ascending are sometimes hurt by coming in contact with them. This, of course, takes place more frequently in mountains which present only a continual alternation of descent and ascent, valleys and ridges, ravines and depressions; and less in those where the mountain-mass extends in a level plain, with but a slightly broken surface. On that account rocky fragments rolling down from the acclivities are rarely met with in Norway, except on the steep masses which lead to the table-land; but they are of daily occurrence in some parts of Switzerland. In the last-named country it sometimes happens that huge masses of rock, crowning the summit of very elevated peaks, descend into the contiguous lowlands, which are many thousand feet lower; and it may easily be conceived that such mountain-slips are almost always attended with the most destructive effects to the countries on which they descend, and to their inhabitants.

It is natural to inquire, in what manner such enormous masses, which sometimes are more than a hundred thousand tons in weight, can be removed from their situation on the top of the mountains, and hurled down to their bases. It is effected by a very slow process of nature. It must, however, be premised that it can only take place in mountains which are stratified, that is, which consist of layers of rocks of different kinds. For when the whole mountain is composed of one kind of rock, which is not stratified, no mountain-slip can occur, though small fragments of it may occasionally be detached and fall down. When, on the other hand, the strata of a mountain consist of different kinds of rock, it may sometimes be the case that the uppermost stratum is less subject to destruction by water than that on which it rests. If under such circumstances the water finds its way through the uppermost stratum, either by rents, which frequently occur in some kinds of rock, or otherwise, it destroys by degrees the lower stratum, carrying off the component particles by torrents, or descending along the rents to the adjacent country. In this manner the whole of the uppermost stratum may be undermined in the progress of time. It loses its base, or at least its principal support, and sinks down on that stratum which was contiguous to that which has been washed away. If the inclination of the last mentioned stratum is but slight, no other change commonly takes place, and perhaps no signs of alteration are observable in the uppermost stratum. But if the lower stratum has a considerable inclination, the uppermost stratum slips down from the inclined plane. The greater the difference is between the summit of the mountain and the country at its base, the greater must be the velocity which the mass attains before it reaches the lower level. In such a case, as may well be conceived, the mountain-mass is broken into numerous pieces, and overwhelms the low country with its ruins. This is the most common case. But it sometimes also occurs that the uppermost stratum itself does not present throughout its whole surface a uniformity in its texture, but that some portions of it are more subject to disintegration than others. In those parts which are more easily destroyed by water, some holes and rents are soon formed, which, continually increasing, gradually take the form of chasms of considerable width. In such depressions water is lodged, which by its weight, and especially when converted into ice, presses against the sides of the chasm, and strives to remove them. In this way single but large pieces of rock may be removed from their site; and if by chance they are standing on the edge of a precipice, they lose their support, and are precipitated down to the lower region.

These mountain-slips are much more frequent than is commonly thought. But as most of them happen in valleys which are not inhabited, or serve only as pasture-ground during a few months of the year, the damage caused by them is not great, and they pass unnoticed. But there are some instances on record where mountain-slips have been attended by the most disastrous effects. More than two hundred years ago a small but rather well-built and pleasant town existed in Val Bregaglia, which at present forms part of the Lombardo-Veneto Kingdom. On the 4th of September in 1618 this place, with an adjacent village, was buried under the ruins of Mount Conto, at the base of which it was standing. The number of persons who lost their lives amounted to 2430. Only three of the inhabitants of the town were saved, because they had left it on some business; and only one house remained standing. The course of the river Mera, which washed its walls, was stopped for two hours, but fortunately it worked its way through the ruins and rubbish. For the ten years previous to this catastrophe it had been observed that several large chasms had been formed on the side of the mountain, but nobody paid much attention to them. From the 25th to the 29th of August there were very heavy falls of rain, and again from the 1st to the 3rd of September. These were considered as the immediate causes of the slip. On the 4th the weather was serene and pleasant, but in the afternoon some rubbish, composed of rocky fragments, came down from the side of Mount Conto. In the following night, whilst the air was quite calm, and the sky cloudless, the summit of the mountain rushed down with a most terrible crash, and buried the town. At present the ruins of the mountain are overgrown with a forest of chestnut-trees.

Where the cantons of Valais and Pays de Vaud border on one another is a table-land, which is so elevated that its surface is partly covered with snow and partly with glaciers. Out of this great snow-field rise the Diablerets or Devilshorns, large and very pointed peaks, which attain an elevation from 10,000 to 11,000 feet above the sea-level. At present there are only three of them, but in the beginning of last century there were four. One of them has slipped down, and scientific persons who have examined the country in this vicinity have found it covered to such an extent with broken pieces of rocks, stones, and rubbish, that they have come to the conclusion that in remote times their number must have been still greater. The peak did not slip down at once, but one part fell in 1714 and the other in 1749. Before the first catastrophe a subterraneous noise was heard, and some of the herdsmen, who had brought their herds to the pastures in the vicinity, took this hint and returned home; others, however, were buried under the rocks. When the mount precipitated itself down, the whole country in its vicinity trembled, and a thick smoke rose to a considerable height in the air. It was only dust, which was detached from the rocks when they broke to pieces. The compression of the air was so great that some of the trees which were near the places along which the rocks descended were bent to the ground or broken. Many of the summer huts of the alpine herdsmen were destroyed, fourteen persons lost their lives, and a large number of cattle and sheep were killed.

One of the herdsmen belonging to the village of Aven in Valais was among those who had not returned home, and was considered as having lost his life. His children were declared orphans by the court. Three months afterwards, on Christmas-eve, he suddenly appeared in his village—pale, thin, covered with rags, resembling a spectre. All the inhabitants of the village were frightened. The doors of his own house were shut to him. Some people ran to the priest, requesting him to exorcise the supposed spectre. After some delay the man succeeded in convincing the people that he was alive, and then he told them that in the moment on which the mountain-slip took place he had been on his knees, praying to the Preserver of life, when an enormous fragment of rock, in descending, struck the ground before his hut, and resting, leant over against the rocky wall at the base of which his hut was built. It was immediately followed by a terrible crash, and by an immense quantity of stones and rubbish, entirely covering the piece of rock which protected his hut. When all became quiet, he continued, "I was no longer in fear; I did not lose my courage, and directly I set myself to work to open an issue. A few pieces of cheese, which I had made, were my food, and a rill of water, which descended among the ruins, quenched my thirst. After many days, which I was unable to count in the long darkness of my subterraneous prison, I discovered, by creeping about among the rocks, an opening. I saw again the sun's light, but my eyes were for some time unable to bear it. The Almighty, in whom I always confided, and who always kept alive my hope of preserving life, has sent me back to my family, to be a witness and a proof of his power and bounty."

The second mountain-slip of the Diablerets, which took place in 1749, was attended by the same phenomena. None of the inhabitants of the vicinity lost their lives, as all of them had removed from their places as soon as the subterraneous noise from the mountain was heard. But five citizens of the canton of Berne, who were in the neighbourhood on business, heeding not the admonition of their host, were buried under the ruins, and it is thought that the house in which they were is five hundred feet under the present surface. So large was the quantity of rocks, stones, and earthy matter brought down by this mountain-slip, that it covered a great extent of good pasture-ground, which continues to this day to be a mere waste.

The most remarkable of these mountain-slips occurred in the beginning of this century, in 1806; and as it happened in a part of Switzerland which perhaps is visited more than any other by every species of traveller, our information respecting the catastrophe is more complete and correct than on those which have taken place in more remote times, or at places not much visited by foreigners. By this mountain-slip the Vale of Goldau, to an extent of more than three miles in length, and all the contiguous slopes, were covered with rocks; and five villages, with their inhabitants, buried under the ruins.

The Vale of Goldau, as it is still called, extends from north-west to south-east about six miles. On its north-eastern side stands Mount Ruffi, also called the Rossberg, which rises to 3747 feet above the Lake of Zug, and on its south-western side Mount Righi, so well known to all those who have visited Switzerland, as hardly any person omits ascending its summit for the pleasure of enjoying a view, which for beauty, variety, and grandeur does not yield to any other known on the surface of the globe. The summit of Mount Righi is 4644 feet above the level of the Lake of Zug. The Vale of Goldau, which lies between these two mountains, consists of two inclined planes of nearly equal extent, of which one terminates on the north-west, on the banks of the Lake of Zug, and the other descends to the northern extremity of the Lake of Lowerz, which is of smaller dimensions than that of Zug. Both the above-named mountains are stratified, and consist of conglomerate; that is, their material is composed of rounded and smooth fragments of stone of various kinds and different size, fromthe smallness of a single grain of sand to pieces containing fifty cubic feet. This material is cemented together into one mass, either by a kind of sandstone or by a fine-grained marl. The strata are of different thickness, sometimes amounting to several hundred feet. Mount Ruffi has along its northern declivity a steep descent, but towards the Vale of Goldau it has a more gradual slope, presenting in general a plane, which forms an angle of 25° with that of the horizon, whilst Mount Righi rises from the vale with a steep acclivity, and its strata have their inclination directed to the south.

More than fifty years before the catastrophe of 1806 large rents had been forming in the mountain mass of Mount Ruffi, along its southern declivity, which by degrees attained a great depth, and by which water was continually penetrating into the interior of the mountain. It appears that these rents passed through the uppermost stratum of the conglomerate, which was united to that on which it rested only by a layer of marl and clay. This was washed away by the water, which was copiously conveyed by the above-named rents. The snow-falls in the winter preceding the catastrophe had been uncommonly heavy, and much rain had fallen during the months of July and August. On the 1st and 2nd of September the rains were incessant, and very abundant. The attention of the inhabitants of the vicinity had been roused, on the morning of the 2nd September, by some unusual noises proceeding from Mount Ruffi, which became more frequent in the afternoon, and also by some pieces of rocks, which descended from its declivities. Towards five o'clock in the evening some much larger masses of rock detached themselves from the summit of the mountain with a loud crash, and descended to the lower grounds. A few minutes later a horizontal rent became visible, which passed throughout the upper part of the mass, at a great distance from its summit; and, at the same time, a portion of the mountain, with its forests and buildings, was seen to be in a slow motion towards the lower grounds. The spectators were put into a great consternation at this sight, and when they raised their eyes towards the summit of the mountain, they saw the whole mass which was above the horizontal rent detach itself from its base, and begin to move downwards, at first slowly; but its velocity increased rapidly, and at last it rushed down with a most frightful crash. At this time the air was filled with clouds of dust, which prevented the observers from tracing the farther progress of the masses. As these persons were standing near the base of Mount Righi, on an elevation of about 300 feet above the vale, they thought themselves out of the reach of any danger from the descending rocks, but they soon observed that a torrent of rocks approached the house in which they were. Large fragments, many hundred pounds in weight, were hurled by the great impulse which they had received by their fall from the summit of Mount Ruffi, to the hill, which they ascended, rebounding until they stopped at a short distance from the persons who witnessed this horrible phenomenon.

Such is the account of eye-witnesses. In examining it, it is evident, according to the laws of nature, that two slips had taken place, which must be distinguished. The whole process began with the slip of the lower and less inclined declivity. It is probable that the upper stratum of this declivity, too, had been loosened from its base by a marly or mouldy layer having been removed by the water. As soon as the motion of this mass had commenced, the horizontal rent under the summit of Mount Ruffi was observed. That portion of the summit which, by the removal of the lower declivity, had lost its support, began to detach itself from its base by inclining towards the south, and thus originated the visible rent. Then the summit tumbled down, by which the most elevated part was hurled to the greatest distance. Immense pieces of rocks, which had been lodged there, were flung over the lower ones, and carried to the base of Mount Righi. The descent of the lower declivity was properly a mountain-slip, and that of the summit a mountain-fall.

The mountain mass had come to the ground in the middle of the vale, at a nearly equal distance between the two lakes; and at this place, at present, a ridge of some elevation is found, which is crowned by many rocks of huge dimensions, rising in the form of peaks above it. Several of these rocks are so immense, that a large building could be hewn out of them. From this ridge the smaller pieces and earthy matter have rolled to the north-west and south-east. On its descent to the north-east, they overlaid the village of Goldau, and on the south-east that of Busingen, and in part also the village of Lowerz. Ober and Unter Rother were villages built nearer the base of the mountain, and had first been buried under its ruins. A portion of the matter which descended to the south-east filled up a part of the Lake of Lowerz. The velocity with which it fell into the lake caused two or three large waves, during which the water rose above the island of Schwanau, though it is sixty feet above the level of the lake, and rushed with great violence over the lower portion of the village of Seven, which stands on the banks of the lake, about two miles' distance from the place where the stony masses entered its waters. All the buildings of stone which were reached by the waves were destroyed. The extent of the country covered with the stones and rubbish between the two lakes is about three miles, and in the opposite direction it is still greater. Its area probably exceeds ten square miles.

Some pains have been taken to determine the size of the rocky mass which was hurled down from the summit of Mount Ruffi, but that has been found impossible for obvious reasons. Its width has been estimated to have been somewhat less than three furlongs near the summit, but towards the lower extremity it must have been much greater. Its thickness was very various, and cannot be ascertained in most places. Towards the eastern extremity it amounted to more than two hundred and fifty feet. According to a vague statement it was nearly three miles long.

In five minutes—for the whole catastrophe did not take up more time—the beautiful and well cultivated Vale of Goldau, with its fields, orchards, and pastures, was converted into a waste. The government of the canton of Schwyz has been at considerable pains to ascertain the extent and amount of the damage produced by this mountain-slip. It was found that the number of dwelling-houses which had been destroyed amounted to ninety-seven, and that besides eight others had been greatly damaged. The number of stables and other outbuildings which had been buried and broken down was one hundred and sixty-six, and nineteen others had suffered more or less. Four hundred and eighty-four persons lost their lives, and one hundred and ten head of cattle, and one hundred and three head of sheep and goats, were killed. Among those who perished were sixteen persons who were not inhabitants of these places, but had come there on business or for other purposes.

The whole amount of the loss of property, according to very detailed accounts, was, on the lowest estimate, equal to nearly 90,000*l.* sterling.

Scientific persons, who have closely examined that portion of the summit of Mount Ruffi which has remained standing, are of opinion that in the progress of time it may also be hurled down by a similar process of nature; and, in fact, a comparatively small piece broke loose in 1823, and fell on those places which formerly had experienced that fate. A small chapel has been built on the place where formerly the village of Goldau was standing, in which the pious Swiss annually convene on the 2nd of September, to pray God to preserve them from a repetition of such a frightful catastrophe.

SECTION V.—THE ICEBERGS AND ICE-FIELDS.

It must be in the remembrance of the reader, that in 1841 a large steam-vessel, the President, which had left New York for England, did not arrive at the place of its destination, and has not since been heard of. There is no doubt that it has been destroyed, but none of the crew and its numerous passengers escaped to give an account of the circumstances which led to its destruction. When it had become a certain fact that the vessel had been destroyed, the relations of those who had perished, and other persons who took interest in their untimely end, began to start conjectures by which they tried to account for the loss of the vessel. After maturely considering all the probabilities, the conclusion was come to that the President must have got between large masses of ice, by which it was crushed to pieces. That such an event is far from being beyond the limits of probability, may be inferred from what happened in 1821 to the brig Anne of Poole. This vessel, on its return from Newfoundland to England, left Greenspond on the 19th of January, and in the evening of the same day it encountered several floating islands of ice. On the following morning by sunrise the ship was so completely beset with ice, that no means of escape were visible, even from the top of the masts. The ice in its whole extent rose about fourteen feet above the surface of the water. It drifted towards the south-east, and bore the ship along with it for twenty-nine successive days. It was only on the 17th of February that the captain perceived an opening to the south-east, by which he made a successful attempt to disengage the vessel.

In the year in which the President was lost, the Atlantic Ocean was more thickly beset with icy masses, and at an earlier season, than commonly takes place. This we learn from a report of the Great Western, which was published in New York. This steamer left England towards the middle of April, and met between 42° and 43° of latitude, and between 48° and 50° of longitude, with an icefield which extended for more than a hundred miles in the direction from east to west, and the vessel proceeded along the southern edge of this mass on the 18th and 19th of April. This edge was lined by a broad border of loose ice, consisting of numerous floes and icebergs, and a great quantity of drift-ice. To make its way through these floating masses the steamer was frequently compelled to change the direction of its course, lest it should come in contact with some of them and be damaged. The number of icebergs which were in sight of the vessel amounted, as it is stated, to about three hundred, and the largest was three-fourths of a mile long, and about a hundred feet high. Several others rose to an elevation of from seventy to a hundred feet. The ice-field itself was raised from two to four feet and a half above the level of the sea. In approaching any one of the larger masses the temperature both of the air and of the water was considerably depressed, the first descending to 28° and the second to 25° Fahr. Other vessels traversing the same part of the ocean later in the season found icebergs still there, and it is stated that one of them rose, according to an estimate, to from two hundred and seventy-five to three hundred feet above the sea, and extended from half to three-fourths of a mile.

According to these accounts a very large *ice-field* was met with in the Atlantic south of 45° of latitude. This is certainly a very uncommon event. There is no other instance on record of such fields having ever been met with at so low a latitude, though they are frequent farther to the north. But it is a well established fact that every year large *icebergs* are found in the Northern Atlantic as far south as 40° of latitude. They however do not occur in every part of this portion of the sea, but are limited to the tract which lies between 42° and 50° of longitude, so that they are met with somewhat nearer to the shores of the United States than to those of Europe. They have never been seen east of 42° of longitude, except in 1817. In this last-mentioned year an uncommon event took place. A large body of ice, many thousand square miles in extent, which for time out of memory had constantly occupied a space north of Iceland, suddenly was broken up, and its fragments were scattered over the northern Atlantic. [It will be remembered that this circumstance led to the expeditions of Captains Ross, Parry, Franklin, and Beechey. For as soon as it was known that the ice had disappeared from this region, it was considered probable that by this event the sea had been rendered navigable all the way to the Pole.] In this year single but large pieces of ice were found as far east as 32° of longitude, or at a distance of about eight hundred miles from the western shores of Ireland.

The icy masses which are found floating in the sea are of two different descriptions, and each of them appears to originate in a different way. They are either *sheet ice* or *icebergs*. The sheet ice bears a strong resemblance to that with which the rivers of the northern countries are annually covered. Its upper surface is level, or nearly so, and it is only here and there diversified by low hillocks. When such a sheet of ice is so extensive that its limits cannot be discerned from a ship's mast-head, it is called a field, and these *fields* sometimes cover an area of a hundred square miles and more. When their extent can be seen from a ship's mast-head they receive the name of *floes*. Masses of floating ice of this sheet kind, of various shapes and magnitudes, up to a quarter of a mile in diameter, are called *drift ice*. On the level surfaces of the sheet ice some protuberances are frequently observed rising at times to the height of thirty feet and upwards above their base. They are called *hummocks*, and are produced by pressure, when two fields meet one another. Then the edges of the ice-fields are broken, and these fragments are squeezed upon the ice, where they are set upon their edges, and in that position are cemented by the frost. The thickness of heavy fields is from ten to twenty feet, and they are commonly raised from two to eight feet above the level of the sea. But that part of the field which is above the surface of the water consists partly of snow; for before the month of July it is always found covered with a bed of snow from a foot to a fathom in depth. This snow dissolves by the end of the summer, and forms on the surface of the fields extensive pools and lakes of fresh water.

The other kind of icy masses floating in the sea are the *icebergs*. They project above the surface of the sea like high hills composed of rugged and steep rocks. Some of these masses are of immense size. Navigators have frequently stated, that they have seen icebergs rising from four hundred to five hundred feet above the surface of the sea and extending more than a mile in length. It may, however, be supposed that in such cases some exaggeration has entered into the account, or that an optical deception has taken place, which cannot be a matter of surprise when it is considered that these icy masses are commonly met with in seas where the refraction of light is very unequal, and produces the most extraordinary phenomena. Keeping to facts which have been well ascertained, we find that during the first voyage of Captain John Ross, Lieutenant Parry measured an iceberg which was aground in Baffin's Bay in sixty-one fathoms of water. It was 4169 yards long, 3689 yards broad, and 51 feet elevated above the sea. Its weight was calculated to be equal to 1,292,397,673 tons. Captain Graah, the Danish navigator, examined an iceberg on the eastern coast of Greenland, whose circuit at its base he estimated at 4000 feet, and which rose 120 feet above the sea-level. He calculated that its contents amounted to more than nine hundred millions of cubic feet. The icebergs differ greatly in shape. The most general form is with one high perpendicular side, the opposite side being very low, and the intermediate surface forming a gradual slope. Some few of them have regular flat surfaces, but usually they terminate in acute summits, exhibiting the most fantastic shapes and an astonishing variety in form and appearance. Some of them resemble palaces or churches, or old castles with spires, towers, windows, and arched gateways, others pyramids and obelisks, whilst others exhibit a great resemblance to ships, trees, animals, and human beings: a number of them seen at a distance of a few miles present the appearance of a mountainous country, and have frequently deceived the eyes of experienced navigators. They differ a little in colour according to their age, solidity, or the state of the atmosphere. A very general appearance is that of cliffs of chalk, or of white or grey marble. A few have a bluish or an emerald-green colour. The sun's rays reflected from them sometimes give a glistening appearance to their surface, so that they appear to be made of silver. In the night they are readily distinguished even at a distance by their natural effulgence, and in foggy weather by a peculiar blackness of the atmosphere. Thus the danger with which the navigator is threatened by them is much diminished.

The origin of the icy masses floating in the sea has, for a length of time, been a point of controversy among natural philosophers. In observing the process of nature in forming ice, it has always been found that at first the water contiguous to the shores of the sea or the banks of the rivers and lakes was converted into its solid form. Hence it was concluded that the vicinity of land was an indispensable condition for that purpose, and this principle was also applied to the formation of the ice floating in the sea. It was supposed that all those bodies of ice had originally been formed along the shores of the contiguous land, whence they had been detached by the waves and the swell of the sea. When floating in the sea, they had by degrees obtained their immense size, especially by the frost's cementing several pieces together into one large field. But there arose a doubt respecting this fact, when the immense quantity of ice was considered which annually flows down from the Poles to the lower latitudes, and which is dissolved and dissipated by the action of the waves and the warmth of the climate into which it drifts. Nevertheless, no diminution of the supply is observed, which certainly could not be so great, if all the ice was to originate along shores of a comparatively not large extent. It is therefore probable that the ice is formed in the open sea, though we are unable to explain the manner in which it takes place. This cannot be a matter of surprise, when it is considered that we are not better acquainted with the manner in which the floating ice of rivers originates, though the operation of nature in these waters is placed much nearer to the observation and examination of the philosopher. It is certain that in the rivers too the floating ice is not originally formed along the banks, but where and how cannot be determined.

These doubts respecting the formation of the ice in the sea have only reference to the sheet ice, for as to the icebergs it has been ascertained, beyond all doubt, that they originate on the land, being nothing more than *large fragments of glaciers.* By far the larger number of them, as it appears, originate on the coasts of Greenland, south of 67° and 68° of latitude. As far as we have any information respecting the interior of this part of Greenland, it presents nothing to the view but a succession of mountains rising far above the line of congelation. They are consequently always covered with snow. The valleys and depressions which occur between them are filled up with ice, derived from the higher portions of the mountains, and thus converted into immense glaciers. In this manner a country of many thousands of square miles is buried under masses of perpetual ice and snow, the depth of which nobody is able to ascertain. It is easy to conceive what a refrigerating power such immense and uninterrupted masses of snow and ice must exercise on the contiguous countries. Where the mountains terminate, their declivities are overlaid with glaciers of great depth. It is true, on the western shores of Greenland the glaciers only advance at a few places so far as to front the open sea. The mountains sink there generally to a low level at a distance of many miles from the sea-shore, and the intermediate country exhibits only isolated masses of rock, between which are some level tracts free of snow in summer, on which the scanty population of the country have settled. But even on the western coast of Greenland are several places where the mountains, and with them the glaciers, extend to the very margin of the sea. On the eastern shores the masses of ice almost everywhere advance close to the water's edge, and at a few places only a space is left large enough to haul up a boat. These glaciers do not confine themselves to the land, but in most places they encroach on the dominion of the sea, and extend for many hundred feet over its depth, so that the eastern shores of Greenland are almost continually lined with cliffs of ice rising several hundred feet above the base in the manner of a wall. On the western coast, as we observed, only a few glaciers front the open sea, but the continuity of its shores is interrupted by a great number of long friths, which run far inland, and which are surrounded either entirely or in great part by glaciers. If the extent of all the shores of Greenland, in which the glaciers advance to the very sea, were put together, it is probable that they would constitute a coast-line exceeding six hundred miles in length. These are the birthplaces of the icebergs. In giving an account of the glaciers (p. 33 and 34) it was stated that these masses of ice advance every year, probably in consequence of a pressure which proceeds from the interior of the snow-mountains, on which they are dependent. This evidently takes place also on the shores of Greenland. The glaciers advance farther and farther into the sea, but the sea undermines slowly and gradually the base on which the advanced portion of the glacier rests. When this has taken place to some extent, and one of the disruptions occurs, to which the glaciers are frequently subject, that portion of it which is not supported by a firm base detaches itself entirely from the main body, and is precipitated into the sea with a loud detonation. Such a fragment is an iceberg. The natives of Greenland in speaking of such an event say that the glacier has *calved*. This last act of the operation of nature has frequently been observed by the Europeans settled on the western shores of Greenland, and by Captain Graah on the eastern, though this gentleman was not so fortunate as to be an eye-witness of the formation of a large iceberg. He states, however, that he has seen many icebergs which had the semi-transparent and bluish colour, by which the ice of the glaciers is mostly distinguished. But icebergs of such a colour are only met with near the shores of Greenland. It appears that this colour soon undergoes a change, which probably is effected by the foggy atmosphere in which they are usually enveloped. Another circumstance which may be produced in favour of the opinion that the icebergs are only large fragments of glaciers, is—the localities in which they occur in great numbers. Fields, floes, and other masses of sheet ice are floating about in great numbers in the sea which separates Greenland from Spitzbergen, but only a few icebergs are found there, and they are commonly of small size. This is with reason ascribed to the small number of glaciers which are met with in the countries which surround the shores of this portion of the Arctic Ocean. Only a few of them, and these of small extent, are found in Spitzbergen and the northern part of the eastern coast of Greenland. It also does not appear that Captain Parry, in his ever memorable attempt to reach the North Pole over ice, met with icebergs among the large masses which surround the pole on the north of Spitzbergen. On the other hand, icebergs are extremely numerous in the narrow sea which divides Iceland from Greenland, and especially along the shores of the last-named country. There they may be frequently seen by hundreds and sometimes by thousands, lying in a line and forming a sort of barrier along the shore. They are hardly less frequent in Davis's Strait as far north as 68° of latitude, and there too they are of very large size. The localities just mentioned are at the same time the only ones where immense masses of glaciers line the shores of the sea, and where frequently large portions of them are seen projecting considerably over the waves.

Now it may be asked in what manner these immense icy masses, which originate on the shores of Greenland, find their way to the centre of the Northern Atlantic, which they can only arrive at by travelling a distance of more than one thousand two hundred miles from the places of their origin? They are brought down by a powerful current, which, from the place of its origin, is called the Polar current. In tracing the course of this current, it will not only be evident why icebergs are met with so far to the south, but it will also be comprehended for what reason these icy masses are limited to certain parts of the ocean, and are never met with near the shores of Europe, nor along those of Nova Scotia, New Brunswick, and the United States. The Polar current appears to originate under the immense masses of ice which surround the Arctic Pole. Captain Parry, at least, found that these masses were continually moving to the south-west, and this circumstance rendered abortive all his efforts to reach the pole by travelling over the ice. Continuing in the south-western direction, the current meets with the eastern shores of Greenland, and runs along them, first south and afterwards south-west, until it enters the narrow sea which divides Iceland from Greenland. It runs with considerable force, and its width certainly exceeds a hundred miles. Thus it happens that most of the fields and floes, by which the sea between Greenland and Spitzbergen is always encumbered, are carried to this narrow sea, and that only single masses of no great extent are met with to the east of Iceland. To this current it must also be ascribed that the sea between Iceland, Norway, and Scotland, is free from ice all the year round, whilst that portion of the sea which lies to the south-west of Iceland is at times almost choked up with fields, floes, and icebergs. The icebergs are supplied by the coast of Greenland opposite Iceland. These icebergs, as well as the fields and other sheet-ice, would certainly be dispersed over a much greater extent of sea, were they not pressed towards the shores of Greenland by the current, which south of 65° of latitude *runs* along shore, but *sets* directly in shore. In this manner the Northern Atlantic is kept clear from large ice-fields and icebergs; but the eastern shores of Greenland are so beset by them, that the attempts which have been repeatedly made to approach this coast from the sea have always turned out unsuccessful. When the Polar current arrives at Cape Farewell, the most southern point of Greenland, it turns round it, and runs northward into Davis's Strait. Proceeding close to the western shores of Greenland, it continues northward as far as Holsteinborg (67° N. lat.), where, from causes not yet ascertained, it suddenly turns west, and proceeds to Cape Walsingham, on the western side of Davis's Strait. From this point it runs southward, along the shores of the American continent to Labrador. By these changes in the direction of its course, the Polar current sweeps away all the icebergs which are formed on both sides of Greenland, and carries them to the Atlantic. What immense quantities of ice are brought down in this way from the eastern shores of Greenland may be inferred from the statement of Captain Graah, that it forms in summer a belt round Cape Farewell from a hundred and twenty to a hundred and sixty miles in width, in which the ice is so closely packed that no vessel can venture to enter. Along the coast of Labrador the current following the coast-line gradually changes its southern into a south-eastern course, and carries the icy masses along the north-eastern shores of Newfoundland, and across the Great Bank, to the centre of the Northern Atlantic, where it meets with and merges into the Gulf Stream.

The icebergs are commonly found in the centre of the Northern Atlantic south of 45° of latitude from May to July, and rarely at any other season of the year. In winter no ice is found here. This fact seems to be the reverse of what might be expected, and, therefore, this circumstance requires an explanation. This is found in the fact that the Polar current does not run all the year round, but is subject to a regular interruption. At Cape Farewell it ceases to run in the middle of October, and from that time up to the middle of January no perceptible current is observed in the vicinity of the cape. This extraordinary fact has only lately come to our knowledge, and as yet no satisfactory attempt has been made to account for it. It is, however, certain that between October and the middle of January the sea round the cape is free from ice, and at that season it may be approached by vessels with safety. About the middle of January the current again begins to run, and it is closely followed by the appearance of icebergs and fields. Following the impulse of the current, these masses make the above-mentioned circuit round Davis's Strait. They employ, as it appears, about two months in making this way, as in the middle of March they are observed to arrive at the coast of Labrador, north of Newfoundland. In these parts a large portion of the sea continues to be covered with icy masses for about three months, from March to June. Later in the season, in July and August, only some streams, composed mostly of floes and drift ice, are met with in these seas. They are commonly of comparatively narrow width, from about five to ten miles. It is in this season that the vessels of the Hudson's Bay Company can venture to force their way through them. If they were to try at an earlier period of the year, they would be wrecked. When the ice arrives in March near the coasts of Newfoundland, it is peopled by numerous herds of seals. This circumstance the inhabitants of Newfoundland have lately begun to turn to account. From three to four hundred vessels are annually sent from different places of the island to the icy masses in pursuit of seals; and though this branch of industry is beset with many dangers, and carried on with an annual loss of life, it is preferred to the coast fishery on the Great Bank, because much more lucrative. This fishery closes when the quantity of ice begins to diminish, which commonly happens at the end of May. From these facts we may infer that the greatest number and the largest of the icy masses pass round Cape Farewell between the middle of January and the end of April, and that after that time the supply gradually diminishes, until it ceases in October.

This is the route the icy masses take every year in advancing to the centre of the Northern Atlantic. Those by which the brig 'Ann' of Poole was surrounded in 1821, and the large ice-field met in 1841 by the 'Great Western,' must have got there by another way. Probably they had only advanced to Cape Farewell or its neighbourhood when the current ceased, and were left there to drift about. But in what way the one got so far southward as to be found near the Great Bank in January, and the other even to 43° N. lat. in April, we have no means of determining.

The dangers to which vessels are exposed in navigating the seas where these masses are floating, are various and numerous. In the seas south of 50°, where commonly only single icebergs and floes are met with, the dangers are not great, and may easily be avoided by attention. But in the seas surrounding Greenland, and extending on the east to Spitzbergen, which are annually visited by numerous whaling vessels, icy masses of every description are floating about in all directions in countless numbers; and as they move with different degrees of velocity, the vessels are frequently entangled and beset by them. It is, indeed, strange that a greater number of these vessels are not lost than is actually the case. Still the loss is sometimes very considerable. The Dutch have lost as many as seventy-three sail of ships among the ice in one year. In the season of 1684 fourteen of their ships were wrecked and eleven more remained beset during the winter. In 1835 several British vessels were lost, and eleven were beset there during the following winter.

Though the icebergs have a more terrible appearance, and strike the imagination more, they are less dangerous than the ice-fields. It is generally found that a strong current runs along the sides of an iceberg, and by this current a vessel approaching too near the berg is sometimes violently forced against the mass and staved. To another description of danger the whaling vessels are exposed by mooring to icebergs. This is frequently done for shelter. The situation of the icebergs in smooth water is very little affected by the wind, and under the strongest gale they are not perceptibly moved, but, on the contrary, have the appearance of advancing windward, because every other description of ice moves rapidly past them, on account of its finding less resistance from the water, and consequently drifting faster to leeward in proportion as its depth beneath the surface is diminished. From the iceberg's firmness it often affords a stable mooring to a ship in strong adverse winds, or when it is incommoded or rendered unmanageable by the accumulation of drift-ice around. The fisher then moors under the lee of the iceberg, the loose ice soon forces past, the ship remains nearly stationary, and gets thus a clear sea. But this operation is frequently attended with considerable danger. The icebergs are often very nicely poised. If a large piece of ice breaks off from one side, the whole mass is suddenly and rapidly turned over, by which event vessels have often been staved, and sometimes wrecked, whilst boats have been upset even at a considerable distance by the vast waves produced by the sudden change of position of the iceberg. Sometimes vessels moor to an iceberg when in want of water. They obtain it from the deep pools which in the summer season are found on the depressed surface of some bergs, or from the streams running down their sides. The water is brought to the vessel with the greatest ease and dispatch. For this purpose casks are landed upon the lower icebergs, filled and rolled into the sea; but from the higher, the water is conveyed by means of a long tube of canvas or leather into casks placed in the boats at the side of the ice, or even upon the deck of the ship; but if, meanwhile, the iceberg should fall into pieces, the vessel is buried under its icy mooring.

The navigation among ice-fields and floes is beset with much greater dangers. The fields frequently have a rotatory movement: it appears to be produced by the different force with which the current acts on the different sides of such a large body of ice. By this movement their outer borders acquire a velocity of several miles per hour. A field thus in motion coming in contact with another at rest, or, as it at times happens, with one which has a contrary direction of movement, produces a dreadful shock. It is easy to comprehend that a body of more than ten thousand millions of tons in weight, meeting with resistance when in motion, produces effects which it is scarcely possible to conceive. The weaker field is crushed with an awful noise; sometimes the destruction is mutual. Pieces of huge dimensions and great weight are frequently piled upon the top, to the height of twenty or thirty feet, while a proportionate quantity is depressed below. That a ship placed between the two fields would not escape destruction, is easily to be imagined. Numbers of whalers have been destroyed in this way. Some have been thrown upon the ice, some have had their hulls completely torn open or divided into two, and others have been overrun by the ice and buried beneath its heaped fragments.

"In the year 1804," says Captain Scoresby, in his 'Account of the Arctic Regions,' "I had an opportunity of witnessing the effects produced by the lesser masses in motion. Passing between two fields of ice newly formed, about a foot in thickness, they were observed rapidly to approach each other, and before our ship could pass the strait, they met with a velocity of three or four miles per hour. The one overlaid the other, and presently covered many acres of surface. The ship proving an obstacle to the course of the ice, it squeezed up on both sides, shaking her in a dreadful manner, and producing a loud grinding or lengthened acute tremulous noise, according as the degree of pressure was diminished or increased, until it had risen as high as the deck. After about two hours the motion ceased, and soon afterwards the two sheets of ice receded from each other nearly as rapidly as they had before advanced. The ship in this case did not receive any injury, but had the ice been only half a foot thicker, she might have been wrecked."

To give an idea of the complicated dangers to which the whalers are frequently exposed in these seas, we extract the following passage from the same author, 'Voyage to the Northern Whale Fishery.' During a gale, attended by a heavy fall of snow, he had moored his vessel to a floe. "About 6 P.M.," he says, "the snow became so thick that we could scarcely see a hundred yards distinctly, and the wind was, if possible, more furious.

Two small icebergs now appeared setting towards the ship; but as they were not of a magnitude sufficient to endanger us without auxiliary pressure, we quietly awaited their approach. The first, which was about thirty-six feet above the level of the sea, struck the ship on the starboard quarter, and turned her broadside to the wind; it then slipped clear, without occasioning us any damage whatever. The second iceberg approached us with more alarming rapidity; but as we had not the power of getting clear of it, we were obliged to receive the shock upon whatever part of the ship it might chance to fall. It came in contact with the rudder, and slightly bruised one of its timbers; then grazing the ship's quarter and broadside, it passed forward to the bows, and being fortunately kept from close contact aloft by a tongue projecting from its base, it cleared all our boats. At this juncture, when the ship was so much involved with icebergs as to render casting off impracticable, had the state of the weather permitted it, two floes came in sight from different quarters. One of them appeared to be rapidly closing upon us from the west, and the other from the south, which, with the floe that we were moored to occupying the eastern quarter, almost completely locked us in. To secure ourselves as far as possible against the crush which now appeared certain, we fastened by a hawser a large heavy piece of ice ahead of the ship where the floes threatened the first contact, with the view of subjecting the interposed mass to the pressure, and with the hope of being then defended from partaking of it. The first shock of the floes was sustained by this mass with full effect, and for some time afterwards all things seemed quiet and safe. Suddenly, however, the pressure was renewed, in consequence, it was supposed, of some new stoppage to the drift of the floes with tenfold violence. Our barrier was squeezed deeply into the floe, and prodigious blocks of ice were broken off and raised up by the pressure. While we contemplated their mighty effects with much anxiety, the berg which shortly before had passed the ship began a revolving and a retrograde motion, so quick as to overtake us before we could get the ropes off to slack astern, and suddenly nipped the ship on the larboard beam and bow against the floe by which we rode. The force was irresistible: it thrust the ship completely upon a broad tongue (or shelf under water) of the floe, until she was fairly grounded, and continued to squeeze her rapidly up the inclined plane formed by the tongue, until the ice came in contact beneath the keel. This was the work of a few moments, and in ten minutes all was again at rest. When the pressure ceased, we found that the ship had risen six or eight feet forward, and about two feet abaft.

"The floe on the starboard side was about a mile in diameter and forty feet in thickness, having a regular wall-side of solid ice five feet in height above the sea; on the tongue of this the ship was grounded. The iceberg on the larboard side was about twenty feet high, and was in contact with the railing of the bows, and with the gunwale and channel-bends amidship. This berg was connected with a body of floes to the westward, several leagues in breadth. The only clear space was directly astern, where a small interstice and vein of water was produced by the intervention of the bergs. Any human exertion for our extrication from such a situation was now in vain, the ship being firmly cradled upon the tongue of ice which sustained her weight. Every instant we were apprehensive of total destruction, but the extraordinary position of the ice beneath her was the means of her preservation. The force exerted upon the ship to place her in such a situation, must evidently have been very violent. Two or three sharp cracks were heard at the time the ship was lifted, and a piece of plank, which proved to be part of the false keel, was torn off and floated up by the bower, but no other serious injury was yet discovered. Our situation, however, was at this time as dangerous and painful as possible. Every moment threatened us with shipwreck, while the raging of the storm, the heavy bewildering fall of sleet and snow, and the circumstance of every man on board being wet to the skin, rendered the prospect of our having to take refuge on the ice most distressing. We remained in this state of anxiety and apprehension about two hours. On the one hand, we feared the calamity of shipwreck; on the other, in case of her preservation, we looked forward to immense difficulties before the ship so firmly grounded could be got afloat. While I walked the deck under a variety of conflicting feelings, produced by the anticipation of probable events, I was suddenly aroused by another squeeze of the ice, indicated by the cracking of the ship and the motion of the berg, which seemed to mark the moment of destruction. But this renewed pressure, by a singular and striking Providence, was the means of our preservation. The nip took the ship about the bows, where it was received on a part rendered prodigiously strong by its arched form and the thickness of the interior fortifications. It acted like the propulsion of a round body squeezed between the fingers, driving the ship astern, and projecting her clear of all the ice fairly afloat with a velocity equal to that of her first launching!"

When we consider the immense size of some of the ice-fields, which sometimes cover an area of several hundred square miles, it seems hardly possible that such a body of ice could be destroyed by the natural effects of a warm climate, the action of the atmosphere, and the power of the waves, and that within the space of two or three months. If these natural powers alone were acting, it is probable that the ice-fields would preserve for a much longer time their consistency, and that they would advance much farther to the south than they usually do. Their destruction, however, is much accelerated by the icebergs and by the swell of the sea. The icebergs, being more compact masses, settle much deeper in the sea. Some of them have been found to reach fifty or sixty fathoms below its level, whilst the more heavy ice-fields hardly ever sink to a depth of more than twenty feet,—or at the utmost twenty-five. This difference greatly affects their respective motions, that of the ice-fields being much quicker, probably because the current runs with greater rapidity on the surface of the sea than at a greater depth. When under such circumstances a field of considerable thickness meets in its way an iceberg, the field is commonly ripped up in all its length, and broken up into floes. Still greater is the effect of the swell of the sea. The fields are commonly surrounded by a border of drift-ice, interspersed with floes, and in this state the swell affects them but little, as these smaller masses break the swell, and prevent it from reaching the great mass. But when this border has been driven off or melted away the effect is astonishing. A swell, which is so inconsiderable that it would hardly be observed in open water, frequently breaks up the largest fields, and converts them wholly into floes and drift-ice in the space of a few hours. As both the icebergs and the swell of the sea operate so powerfully to the destruction of the ice-fields in their long way from Davis's Strait to the centre of the Atlantic, it cannot be a matter of surprise that an ice-field has never been found south of 45° N. lat., with the exception of that which, as mentioned before, was met with by the 'Great Western.'

Icebergs are not affected by the swell. They rise and fall with a tremendous noise, but their size and form remain the same. But when acted upon by the sun, or by a temperate atmosphere, they become hollow and fragile. Large pieces are then liable to be broken off, and fall into the sea with a terrible crash. When this takes place the iceberg loses its equilibrium, turning sometimes on one side, and being occasionally inverted. The sea is thereby put into commotion, fields of ice in the vicinity are broken up, the waves extend, and the noise is heard at the distance of several miles. Sometimes the rolling motion of the berg not ceasing, other pieces are loosened and detached until the whole mass falls asunder like a wreck. Few only of the icebergs, it appears, are destroyed in the northern seas. A large number of them, at least, get as far as the Great Bank of Newfoundland, which is occasionally crowded with them. But many smaller ones are dissolved with the heat of the more southern sea into which they advance, and the larger ones get aground on the banks, where they remain stationary until their size has been so far diminished that they again get afloat, and then they are carried farther to the south by the current. But the number of floes which are found south of 43° N. lat. is comparatively but small, and those which get into the Gulf Stream are quickly dissolved by its warm water, and by the warm and moist air which is superincumbent on that current. Therefore all the icebergs which are met with south of 42° N. lat. are all in a state of rapid decay, but they may be dangerous to vessels in the night-time, if the thermometer is not attended to. For it has always been observed that in approaching an iceberg in these seas the thermometer descends gradually fifteen or twenty degrees. In the month of May it lowers from 60° or 62° to 45° and 40°. When such a sudden and great change in the temperature of the air is observed, the navigator may be certain that his vessel is in the vicinity of an iceberg, and he will soon be aware how to avoid the danger of striking against it.

SECTION VI.—THE GULF STREAM.

THE surface of our globe is composed of land and water. By far the greater part is covered with water, as, according to a rough calculation, the seas extend over about three-fourths of it, the remaining fourth only being occupied by land. The water of the sea is salt, less so towards the poles, and more so towards the equator. This is, with some reason, considered as a wise arrangement of Providence; for if this enormous body of water were ever to fall into a state of stagnancy, it would, if consisting of sweet water, soon become putrid, the more so as it is well known that numerous and large quantities of lifeless vegetable and animal matter are found in the sea, which are in a continual state of decomposition. The noxious exhalations which in such a case would arise from this stagnant body of water would speedily infect the whole atmosphere, which would thus become the source of innumerable diseases for all living creatures. It is to be apprehended that the land would become uninhabitable for man and beast, and be converted into a desert. Though it cannot be denied that this effect is fully prevented from taking place by the saltness of the sea-water, it appears in this, as in many other cases, that nature is gifted with other means tending to produce the same effect. Even if the sea-water was sweet there could hardly be any reason for apprehending such noxious effects, when it is considered that perhaps no portion of the ocean is for any length of time in a stagnant state, and that nearly the whole of its surface is almost always in motion.

The movements to which the ocean is subject originate in different phenomena. Those which are produced by the tides are less extensive than the others. By the tides the surface of the sea is indeed alternately raised by some feet, and let down again; but it can hardly be asserted that by this remarkable operation of nature any portion of the sea is forced from its situation and compelled to change its place, except where the sea borders on land, and even there this effect is circumscribed by comparatively narrow limits. The winds have a much greater power to displace the water of the surface of the sea. They propel the upper stratum in the form of waves, and wherever they continue to blow from the same quarter for any length of time with some force, the whole surface is found to be in motion to the leeward. This is especially observable in those parts of the ocean which are subject to perpetual or periodical winds. The whole surface of the oceanic regions which are swayed by the perpetual or trade winds moves without interruption to the westward, at the rate of about twelve miles every day. This movement is still greater in those parts of the sea where the monsoons and periodical winds prevail, because these winds blow in general with greater force than the trade-winds; but in these regions the motion of the sea changes, of course, with the change of the monsoons. In those parts of the ocean where the winds frequently change the quarter from which they blow, and as frequently, if not more frequently, increase or diminish in strength, the motion of the surface-stratum becomes as it were neutralized by these changes, and is rarely of such a description as to be perceptible. The motion of the surface-stratum of the sea caused by the pressure of the winds goes by the name of *drift*. It does not appear that this effect of the winds extends to a great depth under the surface. For, according to the most authentic accounts, the waves, during the greatest gales, do not exceed sixty feet in a perpendicular line in height, and as by experience it is known that the effects even of a heavy gale are not felt at a depth of more than twenty feet under the hollow of the wave, we may presume that the motion of the drift does never extend to a depth of a hundred feet under the crest of the waves.

There is, however, still another movement met with in certain parts of the ocean, which certainly involves a much larger body of water, and which apparently extends to the very bottom of the sea. It is known by the name of *current*, or *stream*. These currents are frequently compared with the larger rivers of the continent, but this comparison holds good only so far as both the currents and the rivers are volumes of water moving in a certain direction; but if the width and the depth of the former, and the immense body of moving water in them, are considered, it can hardly be said that there exists between them and the rivers any point of comparison. The direction of most of the currents is not dependent on winds, and they are found to run as frequently north and south as east and west. In running from south to north or from north to south, it happens that they bring the warm water of the intertropical seas to the higher latitudes, or the cold water from the vicinity of the poles to the regions near the equator. Therefore it is found that nearly all currents following these directions are distinguished from the surrounding seas by the temperature of their waters being either higher or lower than that of the seas contiguous to their course.

It is not more than about seventy years that these currents have attracted the attention of navigators, and that information has been collected respecting their direction, velocity, and extent, as well as respecting the temperature of their waters. Many of them are still imperfectly known, though it is obvious that an exact knowledge of them would be very desirable, as they affect, to a considerable extent, the navigation of the seas through which they run.

The best known of these currents is the *Gulf Stream*. This is a vast body of water running from the coasts of North America towards Europe, and bringing the warm water of the Gulf of Mexico to the central regions of the North Atlantic. This current has been more carefully examined, because it traverses that part of the Atlantic which is more navigated than any other part of the ocean, being besides distinguished by its velocity, its great width, and the high degree of temperature of its waters.

The Gulf Stream originates in the Gulf of Mexico, whence also its name is derived. It is properly the efflux of that sea. Its upper course describes a large segment of a circle, and lies between Florida Reef and the peninsula of the same name on one side, and the island of Cuba, the Sal Key Bank, and the Bahama Banks on the other side. With a northern course it reaches the open ocean near 28° N. lat. It continues to move in the same direction, and at no great distance from the shores of the United States, until it arrives at Cape Hatteras, north of 35° N. lat. In this its upper course the body of water in motion occupies a space varying between thirty-six and seventy-five miles, and may in this respect be compared with the wider western part of the British Channel, or with that portion of it which is west of the Bill of Portland. From Cape Hatteras the Gulf Stream runs eastward into the Atlantic, and gradually expands to two hundred miles and more in width. It continues to flow in that direction until it reaches 40° W. long., when it turns gradually south-east and south. In approaching the islands of Corvo and Flores, which are the most western of the Azores, its current becomes weak, and at the south-west of these islands it is lost, and the warm water of the stream is dispersed over the sea. This is commonly the place where the Gulf Stream terminates. But there are instances on record of the warm water of the Gulf Stream sometimes advancing as far eastward as the western coast of Portugal and Spain. The space which the Gulf Stream traverses between its efflux from the Gulf of Mexico to the islands of Corvo and Flores exceeds three thousand miles. When its water reaches the coast of Portugal and Spain it runs about a thousand miles more. These outlines show that the Gulf Stream is a phenomenon of first-rate magnitude, which deserves a more detailed description.

In its upper course, between the place where it issues from the Gulf of Mexico and that where it enters the

Atlantic, the Gulf Stream may in some respects be considered as a vast river. No other current of the globe, at least like this part of the Gulf Stream, runs between banks so well defined on either side. On one side these banks are formed by the Florida Reef and the peninsula of that name, and on the other by the island of Cuba, the Sal Key Bank, and the Great and Little Bahama Banks. These banks are not *banks of sounding*, a term applied to those parts of the sea whose bottom is within the reach of the common sounding-line, which is a hundred fathoms long. The Sal Key Bank and the Bahama Banks are *proper banks.* They rise not gradually, but suddenly, and from a very deep sea. The surface, near the edges of the banks, is but a few fathoms below the common level of the sea, and towards the interior many places are found which are only a few feet under water; some are quite dry at low tide. Besides, at many places along their edges these banks are beset with rocks even with the water's edge or above its level. It is obvious, from this description, that such banks must influence the current precisely as if it were running between banks of land. Accordingly we find that the Gulf Stream, contrary to the nature of other currents, is compelled by these banks to bend in the form of a large segment of a circle. Hemmed in on either side, its waters are not only prevented from spreading, but, as these banks draw closer together as the stream proceeds farther on, the great volume of water is gradually compressed into a much narrower space, by which its velocity is so increased, that before it reaches the Atlantic it has acquired a rapidity which is much superior to that of navigable rivers, and resembles that of a mountain stream.

The place where the waters issuing from the Gulf of Mexico are first clearly perceptible as a current, is found betweeen the harbour of Bahia Honda on the island of Cuba, and the Tortugas Islands, near the meridian of 83° W. long. At this point the sea is about 80 miles wide, and the current runs rather slowly due east past the harbour of the Havannah to Matanzas and Punta de Ycacos. As in all this space the width of the water-way is but little diminished, the current is not much increased in velocity. But at Punta de Ycacos it meets the bank which extends along the northern coast of Cuba, which prevents it from proceeding in a due eastern direction. The stream therefore is compelled to run off to the north-east, where it encounters the Sal Key Bank. Here it enters the Strait of Florida, which at this place is only forty-eight miles wide. The waters which above Punta de Ycacos flowed in a channel eighty miles wide, are at the entrance of the Strait of Florida pressed into a strait not much more than half as wide. Their velocity consequently is so increased, that in summer they run commonly at the rate of forty-eight miles every day. Having passed along the northern edge of the Sal Key Bank in a north-eastern direction, the current rushes with great force against the western edge of the Great Bahama Bank, and is repulsed. The stream is thus compelled to flow along the edge of this bank northward. In this direction it enters the Narrows of the Strait of Florida, where the sea area between Cape Florida and the Bemini Islands is reduced to a width of forty-four miles. But some rocks and reefs which are found on either side of the strait in these parts still further reduce the water-way to thirty-six miles. The immense volume of water which higher up ran through a channel of eighty miles, is in the Narrows compressed into a space of thirty-six miles, and its velocity is consequently greatly increased. Within the Narrows of the Strait of Florida the Gulf Stream runs in summer from eighty to ninety-six miles per day, or from three and a-half to four miles per hour. Sometimes it runs even a hundred and twenty miles per day, or five miles per hour. This is the greatest degree of velocity the Gulf Stream attains, and it is hardly practicable for sailing vessels to stem the current if not aided by a favourable gale. In winter the velocity is commonly reduced to two or two miles and a-half per hour, and as at that period northern winds prevail, it may be ascended. The northern portion of the Strait of Florida, or that which is north of 26° N. lat., gradually increases in width, and where it terminates, at 28° N. lat. it is more than fifty miles wide. Though the waters find here a greater space to expand, their velocity is not much decreased. For at the Maternillo Reef (27° 40′) they continue to run in summer at the rate of eighty miles per day. That portion of the Gulf Stream which hitherto has been noticed is about four hundred miles long. It runs from Bahia Hondo one hundred miles to Punta de Ycacos, and thence sixty to the Sal Key Bank. In the Strait of Florida it flows ninety miles before it reaches the Bemini Islands, and then in the Narrows thirty miles. Below the Narrows the strait is still a hundred and twenty miles long.

As the velocity of the Gulf Stream above Punta de Ycacos is not great, the Gulf of Mexico may be compared to a vessel filled up to the brim, from which the waters flow off slowly at the only place where it can escape. If, in running eastward, the body of moving water was not compressed by the narrowing of its banks, and had met with an outlet as wide as the channel in which it flows farther upward, it would have run off to the Atlantic with a velocity but slightly increased by the pressure of the column of water which urges it on from behind. As it is, the pressure of this column is continually increasing by the decrease of the width of the strait into which it is forced. When the Gulf Stream arrives at the Narrows, the column of water which presses on it from behind is two hundred and fifty miles long, and the channel into which it passes is reduced to much less than its former width. These circumstances taken together account for the great degree of velocity with which the waters pass through the Narrows, and continue to flow until they leave the Strait of Florida. In this part the velocity of the stream may be compared to the *bore* which is found in the Ganges and the Bristol Channel, except that in the Narrows the rush of the waters is continual, whilst at the two places just mentioned the bore is only observed twice in twenty-five hours, being produced by the tide-wave suddenly rushing into a channel which grows continually narrower.

At 28° N. lat. the Gulf Stream enters the Atlantic. It follows, of course, the impulse its waters have received in the Strait of Florida, and runs northward. On the east of the stream lies the wide expanse of the Atlantic, and on the west the shores of the United States. As these shores recede from the current, trending to the west of north, the Gulf Stream is now free from the obstacles which hemmed in its course farther upward, and begins gradually to expand. Opposite to the town of Charlestown it is more than sixty miles wide. Near this place the banks of soundings skirting the American coast prevent the stream from continuing northward, and deflect it to the north-east. In this direction it continues to Cape Hatteras. Opposite this cape the width of the current has increased to seventy-five miles. From its outfall into the Atlantic to Cape Hatteras, the Gulf Stream has traversed a space of five hundred miles. Its velocity has decreased, but less than one would expect, when it is considered that its width has increased to more than double the extent it has at the Narrows of the Strait of Florida. At Cape Hatteras it still runs commonly at the rate of three miles per hour in summer, and sometimes even more. It must, however, be observed, that this degree of velocity is only found in the middle of the stream, and that it runs more slowly towards its borders. This observation applies to the whole course of the Gulf Stream in the Atlantic.

The Gulf Stream may be said to leave the coast of America opposite Cape Hatteras. Its farther course lies across the Atlantic. The waters moving along the outer or eastern border of the stream turn entirely to the east at 36° N. lat.; but those constituting the inner or western border continue to flow to the north-east until they approach 38° N. lat., when they also take an easterly direction. They are compelled to this change in their direction by the banks of soundings which extend along the shores of New York and New England, and are known by the names of Nantucket and St. George's Banks. These banks extend far into the Atlantic, and the Gulf Stream runs at no great distance from their southern edges. At the meridian of 72° W. long. the whole immense body of water is moving eastward. Shortly after it has passed Cape Hatteras, the width of the stream is not less than a hundred miles, and it increases continually in proceeding eastward, so that at 63° W. long., where it is frequently crossed by vessels sailing from the Bermudas to Nova Scotia, it is about one hundred and fifty miles wide. It is there about six hundred miles from Cape Hatteras. It is justly considered as a matter of surprise, that by this long run, and by its expanding to double its previous width, the velocity of the current is so little affected; for at 63° W. long. it is still found to run from two to three miles per hour in summer, in the middle of the stream.

Near 63° W. long. another change is observed. St. George's Bank terminates near 65° W. long. The Gulf Stream having still preserved an inclination to set to the northward, advances gradually to between 41° and 42° N. lat. By this change its width is increased, and it soon attains its greatest breadth east of 60° W. long. In these parts of the Atlantic it hardly anywhere falls short of two hundred miles in width, occupying almost entirely the whole sea between 37° and 41° N. lat. But though its northern border has advanced farther north, the great body of water flows directly eastward. In these parts the velocity of the steam is greatly reduced; for in approaching 45° W. long., or after a run of nine hundred miles more, it is never found to exceed one mile and a half per hour, and sometimes it is reduced to one mile.

Near 45° W. long. the Gulf Stream is joined by a great body of cold water, which is brought down from the seas surrounding Greenland and Labrador by the Polar current. It is this current which, in the months of May, June, and July, brings, from the Arctic regions, a great number of icebergs to the centre of the Atlantic, where sometimes vessels are destroyed by them, of which an instance occurred as late as last year (1844). These enormous icy masses, however, are speedily dissolved as soon as they enter the warm water of the Gulf Stream, and, therefore, an iceberg has never been seen to the south of 40° N. lat.

It appears that its junction with the Polar current affects the direction of the Gulf Stream; for near 40° W. long. the current decidedly sets to the south-east, and gradually it turns to the south. Its velocity abates by degrees, until the current becomes imperceptible to the west and south of the islands of Corvo and Flores, near 31° W. long. and 36° N. lat. Here it may be said that the Gulf Stream terminates. North of the above-named islands, it yet runs, however, from ten to twelve miles per day.

It is very difficult to estimate the width of the Gulf Stream near its termination; for the waters which move along its southern border do not extend so far east as the northern current, but terminate near 42° W. long. Both currents, therefore, cease to flow near 36° N. lat., but at a distance of more than five hundred miles from one another. The space between them must be considered as the mouth of the Gulf Stream.

In the mouth of the Gulf Stream thus defined, a phenomenon occurs of a peculiar nature, but which impresses on this great oceanic river a certain degree of resemblance with our large continental streams. It is found that the Gulf Stream has formed an island within its mouth. It is a well-known fact that nearly all rivers bring down from the countries which they drain large quantities of earthy matter, which they deposit on approaching their mouths, and thus alluvial islands are gradually formed, larger or smaller, mostly in proportion to the volume of water the river contains. Sometimes only one island is formed, but commonly several islands, which are divided from each other by channels. A similar phenomenon is observed also in the mouth of the Gulf Stream. The current indeed does not bring down earthy matter, but in every part of its course single plants of sea-weed, or *fucus natans*, is found swimming. This sea-weed is floated by the current to its mouth, where it may be said to form a number of islands. In no part of the ocean is the sea-weed found in such masses as in the mouth of the Gulf Stream, where it forms a bank of great extent. The resemblance between the fucus bank and the deposits of the rivers extends even to its form. The alluvial islands in rivers are much narrower at their upper than at their lower ends; they gradually get wider towards the place where the rivers reach the sea. The same form is observed in the fucus bank. A few patches of sea-weed only are met with near 40° N. lat., and even farther north. They grow more numerous and larger in proceeding southward, and between 36° and 30° N. lat., and 38° and 42° W. long., the quantity of this weed is really astonishing. It covers like a mantle the surface of the sea for many miles, but usually lies in lines which vary from a few yards to three hundred or four hundred fathoms in width. The weed is frequently found in large patches of irregular shape, but generally of a circular form. These fucus islands extend far beyond the mouth of the Gulf Stream, and may be compared with the deltas of the Mississippi, the Nile, and the river of Cambojah, which extend far into the sea. Patches of gulf-weed occur at a considerable distance south of 30° N. lat., as far as 25° and even farther, but in these parts the patches lie at greater distances from one another. The existence of these banks in such a southern latitude has led to the supposition that the current of the Gulf Stream extends to that parallel, though it has ceased to be perceptible almost ten degrees farther northward.

The width which we have assigned to the Gulf Stream in different parts of its course, refers to the stream itself; it indicates the space in the Atlantic where a current has actually been met with. But the warm water brought down by the stream spreads over a much larger space. As far as the current runs along the coast of America it does not appear that warm water is found to any considerable distance on the sides of the Gulf Stream, but where it traverses the Atlantic it extends to a very great distance from the current. In these parts the Gulf Stream resembles a large river running through a vast plain which is but little elevated above the level of its surface, and which is therefore overflowed every time the surface of the river is raised to a somewhat higher level. In the same manner the Gulf Stream diffuses large volumes of warm water along both its borders. How extensive these overflowings are may be inferred from the fact that the width of the Gulf Stream along the line of navigation between the Bermudas and Nova Scotia, at one time was found to be only one hundred and fifty miles, whilst at another time the warm water covered a breadth of three hundred and twenty miles; the overflowing on both sides, therefore, spread over a space of one hundred and seventy miles in width. Farther to the east the warm water, inclusive of the stream itself, occupies a width varying from three hundred to four hundred miles, though the current itself perhaps nowhere exceeds two hundred miles. Hence it happens sometimes that warm water is found as far north as 45° N. lat., covering the southern extremity of the Great Bank of Newfoundland.

Thus we find that the Gulf Stream and its widely extended overflowings form a body of warm water of great extent in the middle of the North Atlantic. This expanse of warm water extends from 75° to 30° W. long. in length, occupying a space in width at the east end from the 33rd or 34th to the 45th degree of latitude, and being at the west end from 160 to 170 miles wide. Its length therefore, from west to east, exceeds 2000 miles, and its breadth, from north to south, may be taken at a mean to be more than 360 miles. This gives an area of 720,000 square miles, and is equal to four times the extent of France, and larger than the Mediterranean Sea. Sometimes its area is yet greater, and the warm water is found to extend to the very shores of Europe. Dr. Franklin found warm water, in November, 1776, in the sea surrounding Cape Ortugal in Spain; and Captain Sabine, in January, 1822, in the sea between Portugal and the Azores. These facts have led to the supposition that at certain times the supply of warm water brought by the Gulf Stream from the Columbian Sea is more than commonly abundant, and that then the force of the stream is increased to such a degree that the current does not cease at the Azores, but is continued to the shores of the Old Continent.

If the immense area which the warm water of the Gulf Stream covers is a matter of surprise, its high temperature is not less so, especially as it is found to preserve a great part of this temperature to its very termination. It is not difficult to account for the high temperature of the Gulf Stream at its source, as no part of the ocean has so high a temperature as the waters of the Gulf of Mexico. It is found in summer to vary between 86° and 88°, whilst in the open Atlantic, under the same parallel, it is only 78°. Under the equator the temperature of the sea varies in summer between 82° and 84°. The waters of the Gulf of Mexico are therefore four degrees warmer than those under the line. The Gulf of Mexico resembles a vast *cauldron*, employed in heating water for distribution over the central parts of the Atlantic.

It is calculated that the stream in twelve days runs from the Sea of Mexico to Cape Hatteras, a distance exceeding nine hundred miles; and it has been ascertained that the temperature of the water at the last mentioned place is still 83°. This is an astonishing fact, considering that the water has passed through eleven degrees of latitude (from 24° to 35°), and that in this space the oceanic water has diminished six degrees of temperature (from 78° to 72°). How can such an extraordinary fact be accounted for? By what circumstance is the Gulf Stream enabled to prevent its waters from becoming colder in the same proportion as happens with the water of the ocean when it passes through eleven degrees of latitude? There appears to be no other manner of explaining this fact than by supposing that the body of warm water is so immense that it is but slightly affected by the increasing cold of the atmosphere. If only the superficial stratum consisted of warm water, it would soon cool down to the common temperature. We must therefore assume that the warm water reaches to the very bottom of the sea. As none have yet succeeded in ascertaining the depth of the sea at any place within the Gulf Stream, we may assume that the current has scooped out a very deep bed in the bottom of the ocean. This assumption can hardly be questioned when we consider its extraordinary velocity between Sal Key Bank and Cape Hatteras.

After leaving the coasts of America the Gulf Stream expands to a greater width, and its velocity is decreased, as before stated. Its temperature also decreases, but not in proportion to the decrease of velocity or the widening of the current. For after having run in twelve days from Cape Hatteras to 63° W. long., about six hundred miles, and increased in latitude about four degrees, the temperature has only decreased two degrees, being still 81°, or nearly equal to that of the sea near the equator. If this part of its course is added to that before noticed, we find that the water of the Gulf Stream passing in twenty-four days through fifteen degrees of latitude, loses only five degrees of heat. In the remainder of its course the decrease of temperature is more rapid. From 63° W. long. to Corvo and Flores it runs fifteen hundred miles, and passes through this space, according to a calculation which deserves confidence, in fifty-two days. The temperature of its waters is then reduced from 81° to 72°, but even at its termination it is by six degrees higher than that of the contiguous seas.

By comparing the temperature of the Gulf Stream with that of the Atlantic under the same parallel, we find that in the first half of its course, or up to the place where it passes 63° W. long., the water of the Gulf Stream is 12½° warmer than that of the ocean; but in the second half, not more at a mean than 7½°.

Such an immense body of water, heated to such a degree above the temperature of the contiguous seas, and consequently also above that of the atmosphere, must of course greatly affect the air incumbent on it. The difference between the temperature of the air and the water must cause a continual evaporation, in order to affect an equilibrium between the two elements, and the vapours thus generated must render the air warm and damp.

This is just one of the peculiarities by which this region of the Atlantic is distinguished, and it is especially observed in winter. The air at this season is described as being extremely heavy, warm, and damp, to such a degree even as to affect the chronometers, which become irregular. This temperature of the air raises the thermometer to summer heat, sometimes to 80°, whilst it remains near the freezing point beyond the borders both south and north of the Gulf Stream. Every gale, or even a common breeze, must carry this hot air beyond the limits of the warm water, and thus affect the adjacent seas and countries. Few regions in the world perhaps are subject to such sudden and great changes in its temperature as the middle states of the American Union. These changes are produced by the winds suddenly shifting from north or north-west to south and south-east, or *vice versâ*. It may be assumed with much reason that one of the principal causes of these changes is to be found in the warm and moist air incumbent on the warm water of the Gulf Stream.

To the same cause another peculiarity must be ascribed, by which this aquatic region is distinguished—the frequency of gales. There is perhaps no other part of the ocean where the gales are so common as in the seas which lie on both sides of the borders of the warm water. It is therefore supposed that they owe their origin to the warm air coming into contact with the much colder air incumbent on the seas contiguous to the stream. As the two bodies of air differ by many degrees of the thermometer in their temperature, the equilibrium between them cannot be established but by a very violent disruption, and this gives rise to the storms. These gales, and in general every wind encountered in or near the Gulf Stream, have a peculiar character. They do not blow with a continual and regular strength, but in sudden puffs, following one another in quick succession. It may perhaps not be out of place to observe here, that this is also partly the character of our winds blowing from all points between south and west, whilst those from other quarters commonly blow with a regular force, and increase or decrease gradually in strength. This difference in the character of our winds has greatly puzzled all those who have investigated this matter. May it not be that the effects produced by the sudden changes in the atmosphere, in consequence of the evaporation of the warm water of the Gulf Stream, extend to our shores ? and may not also the higher degree of warmth by which south-western winds are characterized in winter, and which doubtless render our winters less constant but also less rigorous than those experienced in the interior of the European continent, be likewise ascribed to the same cause ?

These gales are much dreaded by the seamen, but still more so is the sea where they prevail. Even during the prevalence of common breezes, when they oppose the current, the sea is always heavy and broken, so as to occasion a ship to labour much under any trim of sail whatever. But whenever a gale blows against the current, the sea is agitated to such a degree, and its high waves cross one another so rapidly, that the seamen cannot find words strong enough to express its fury.

These observations prove that the navigation of the North Atlantic is materially affected by the Gulf Stream. When the existence, extent, and velocity of this extraordinary current had been fully ascertained, it was considered as a discovery which would greatly benefit the return voyages from the West Indies. Accordingly, most of the vessels which were bound to Europe, on leaving the Caribbean Sea and the Gulf of Mexico, followed the course of the Gulf Stream in its whole extent, along the American coast and across the Atlantic. It was found that by following this track vessels saved about five days' sailing at a mean, which was a considerable advantage in a voyage not occupying on an average more than forty days. But, at the same time, it was ascertained that the wear and tear of the vessels, by being exposed to almost continual gales and a very heavy sea, was so great that it more than counterbalanced the saving of time. For this reason the track at present is hardly ever followed by merchant vessels. They take advantage of the Gulf Stream for the purpose only of getting out of the region of the trade-winds. Therefore they follow the stream only through the Strait of Florida, and as soon as they have passed Maternillo Bank they turn to the east. As the southern border of the Region of Storms lies between 33° and 34° N. lat., the vessels continue their eastern course south of this parallel, passing south of the Bermudas, and not till they find that they are about 15° east of these islands do they steer direct for Corvo. By keeping this track they avoid at least two-thirds of the Region of Storms. Vessels sailing from the southern and middle states of the American Union to Europe follow the same track. Those which sail from New York to Europe keep to the north of the Gulf Stream until they reach 55° W. long., where they enter its most northern portion, but they leave it again near 45°. This is the most dangerous part of the voyage, as they may here expect gales, and in May, June, and July the icebergs from the Arctic Sea. Vessels sailing from Europe to North America keep either to the north or to the south of the Gulf Stream, according to the seasons.

The human mind is so constituted that it feels an irresistible desire to explain every phenomenon of nature with which it becomes acquainted. As the Gulf Stream is one of the greatest and most singular phenomena, it is, of course, asked whether its origin can be accounted for in accordance with the known laws of nature. Several attempts have been made, but the only satisfactory explanation is that which ascribes its origin to the great accumulation of water along the South American coast, partly the effect of the trade-winds, and partly of the peculiar formation of that coast.

This explanation rests on the well-ascertained fact, that a high wind, by the pressure it exercises on the surface of a body of water, is able to raise the water higher on the lee-side than it is to windward. Instances of this kind are frequent. An attentive observer will easily ascertain in a common pond, when a high wind blows in its longitudinal direction, that that extremity of it which is to the leeward has its level raised by pressure of the wind to an inch and more above its common level. The same phenomenon is still more distinctly perceptible in a canal. Let us take a section of a canal three miles in length, and having at each extremity a lock. If a high wind blows for a few hours in the longitudinal direction of the canal, the water accumulates at the lock to leeward from a foot to eighteen inches higher than at the other end. The same effect is frequently seen in inlets and narrow seas, especially when they are wider to windward than to leeward. It is a well-known fact, that heavy western and south-western winds, when they continue to blow for some days, drive large volumes of water into the British Channel, which accumulate in the Straits of Dover, and raise the level of the strait, it is stated, by ten feet. When this accumulation takes place during the fall and change of the moon, the spring-tides coming from the North Sea are prevented by the accumulated water in the strait from flowing off in the usual way; and it is then that the tides in the Thames rise above their common level, and the lower parts of London are inundated. A very extraordinary instance of the power of the wind to raise the level of a body of water by pressure, has been seen by the author in a river falling into the Baltic. A wind blowing a hurricane, in six hours raised the level of the river, three miles above its mouth, more than thirty feet above its common height, and laid an immense tract of low ground under water. It must be kept in mind, that in all these instances the surface of the water between the lowest and highest point is a slightly inclined plain, which rises towards the leeward, and grows lower towards the point from which the wind blows.

The Gulf Stream is the effect of a similar operation of nature, and the ultimate cause of it are the trade-winds. The winds never blow a gale, but only a moderate breeze. The idea of their force can be conceived when it is remembered that these winds propel a common sailing vessel at the rate of from five to six miles per hour. They blow, however, without interruption, and increase or decrease only occasionally a little in strength. That such a wind is able to move by its pressure the surface-stratum of the sea to the leeward is evident from the fact that south of 28° N. lat., where the trade-winds are met with, the whole surface of the sea is moving westward at the mean rate of twelve miles per day. This being a fact which does not admit of any doubt, it will easily be comprehended that an accumulation of water must take place along the lee-shore, that is, along the eastern coasts of America. If these coasts ran in a straight line north and south, the accumulated waters would run off in a current along the shores, but this current would certainly not be of such a size or velocity as to be compared with the Gulf Stream. The peculiar conformation of the eastern coasts of America between 28° N. lat. and the equator is the cause that along its shores a greater accumulation of water is effected than at any other place of the widely extended ocean.

By a straight line drawn on a chart of the Northern Atlantic, from Cape Race in Newfoundland, to the mouth of the Amazonas River in South America, this sea is divided into two parts. The eastern portion communicates at both extremities with a sea as wide, or nearly as wide, as itself. But the western part is an immense bay, which almost continually grows narrower in proceeding farther west, and which terminates in the Gulf of Mexico. This gulf constitutes the innermost recess of the great Atlantic Bay. All the water put in motion in the North Atlantic by the trade-winds, is driven into this bay, and accumulates within its innermost recesses. In the southern part of the sea, between the equator and 10° N. lat., the drift current of the trade-winds accumulates the water along the coast of Guiana, on which the stream sets obliquely, and is thus compelled to run off along the shores in a north-western direction. This water forms a current, which is known by the name of the Guiana current, and which carries its water to the Caribbean Sea, by the straits found between the South American continent and the island of Dominica. In all these straits the water sets westward into the Caribbean Sea at a rate of about twenty-one miles per day. Farther to the north, between Dominica and the island of Cuba, all the water accumulated by the trade-winds enters the Caribbean Sea, running at the rate of a common drift current, or about twelve miles per day, and passing through the numerous straits between the two last-mentioned islands. It is certainly a remarkable fact, which must not be lost sight of in explaining the origin of the Gulf Stream, that through all the avenues leading to the Caribbean Sea the water of the Atlantic enters as a current, and that in no one of these numerous straits is it ever found to return eastward into the ocean. The whole surface of the Caribbean Sea is likewise moving westward, and being repulsed by the coasts of Central America, it runs off to the northwest and enters the Gulf of Mexico by the Strait of Yucatan. Thus we find that the Caribbean Sea, and ultimately the Gulf of Mexico, is the receptacle of all the waters accumulated by the trade-winds in the North Atlantic.

All these facts tend to impress us with the idea that the waters in the Caribbean Sea and Gulf of Mexico must have a level considerably elevated above that of the Atlantic between the Canaries and the Cape Verde Islands, and that this difference is produced by the continual pressure exercised by the trade-winds on the surface of the North Atlantic. But we have no means to determine this difference by calculations. We can only judge of it by the velocity with which the Gulf Stream carries off the superabundance of waters through the Strait of Florida. If the velocity of the stream was the effect of this difference alone, we should be justified in supposing that it must be very considerable, but it appears that in the Gulf Stream, as in rivers, the velocity is the effect produced partly by the fall, and partly by the column of waters which press from behind.

To render the manner in which the Gulf Stream is formed still more comprehensible to the reader, it may be supposed that the trade-winds are strong enough to raise the surface-stratum of the sea an inch in each mile, and to keep it always at that level. Continuing at this rate through the whole extent of the Atlantic, the level of the ocean in the straits leading to the Caribbean Sea would be more than 200 feet above its level near the Cape Verde Islands, as the distance between them falls not much short of 2500 miles. The same pressure operating on the surface of the Caribbean Sea, which is about 1500 miles long, would raise the level by 125 feet more. The result of such a calculation would be that the Gulf of Mexico is elevated by 325 feet above the North Atlantic near the coast of Africa; and this elevation may perhaps appear sufficient to explain the velocity of the Gulf Stream, when the immense column of water is taken into account which presses on it from behind.

It appears that the water which is put in motion by the trade-winds acquires in its passage from the coast of Africa to that of America a much higher degree of temperature. At a distance of about four hundred miles from the coast of Senegambia its temperature in summer is about 74°, but in the Caribbean Sea it is 82°. This temperature is still raised in the Gulf of Mexico, where a great portion of it certainly remains for a considerable time, on account of the peculiar form of that sea, and because the two channels, that by which it receives its supply of water, and the other, by which it discharges its superabundance, are found at no great distance from one another. The gulf resembles in its form a large segment of a circle, equal to more than three-fourths of the whole. The water, entering into this sea by the Strait of Yucatan, takes two different directions. One portion of it runs directly north-east to the place where the Gulf Stream begins, while another very large portion is carried to the west. This last body of water, running along the coast of Mexico, makes a wide circuit, until, having arrived opposite the mouth of the Mississippi, it turns south-east, and in approaching the Tortugas Islands unites with that body which runs hither from the Straits of Yucatan. As the currents within the Gulf of Mexico are very moderate, it may be easily comprehended that the temperature of the waters during their prolonged stay there is raised from 82° to 86°, or even 88°, as it has been found at many places.

SECTION VII.—THE SAMOOM.

IN countries which border on sandy deserts a very hot wind, which powerfully affects the animal creation, is generally experienced whenever the wind blows thence. In Syria, and at Mekka in Arabia, such a wind blows from the east; in Egypt from the south-south-west and south-west; and at Surat, in Hindustan, from the north; in Senegambia and in Guinea from the north-east. This wind, of course, bears different names in the different countries. In Egypt it is called *khamsin*, and along the western shores of Africa *harmattan*. The Arabs call it *samoom*, which signifies a *burning* or *poisonous* wind, and this term has been adopted in the European languages. In Turkey it bears the name of *samieli*. Many persons think that all these terms are used to indicate the same kind of hot wind, but, in reality, the winds which are designated by them differ greatly in their qualities. Thus, for instance, the harmattan, so far from being poisonous, and causing the death of travellers, is considered by all Europeans settled on the western coast of Africa as a healthy wind, which is also proved by the effects it produces. It blows from the side of the great desert of the Sahara, and, passing over its sandy plains, it acquires an extraordinary degree of heat and dryness, so that even the best seasoned timber shrinks considerably, and all wooden furniture falls to pieces. It produces, also, chaps in the lips, and afflicts many of the natives with sore eyes. But, as it immediately succeeds the rainy season, the changes produced in the atmosphere by the harmattan are greatly desired. During the long rains the air is so loaded with moisture, that the inhabitants of Senegambia may be said to live in a sort of vapour-bath, and everything which is not close to the fire becomes damp and mouldy. The effect of this excess of moisture is extremely hurtful to the health of the inhabitants, especially the Europeans, who are attacked at this period by putrid and malignant fevers, of which a great number die. But as soon as the harmattan begins to blow, this state of things is changed, and persons who have fallen ill during the rains recover their health in a short time.

The samoom, however, of Syria and Arabia is of a very different description. Its effects on the human frame are extremely deleterious, and many of the Mohammedans who go on pilgrimage from Turkey and Persia to Mekka are killed by it, as their road lies through countries extending along the Syrian Desert, where the wind originating in that sandy plain appears to possess more noxious qualities than any other. It always makes its appearance during strong south-western winds, but only between the middle of June and the 21st of September. This wind blows only in short gusts, which are of unequal duration; but even the shortest continue longer than it is possible for any man to hold his breath. The gusts are burning hot, but the intervals are much cooler. The difference of temperature between the gusts and the intervals is said to amount sometimes to ten degrees of Fahrenheit. It is easy to conceive that the human body, exposed repeatedly and suddenly to such a difference of heat, must be greatly affected. During the hot gusts the thermometer in September rises to 78°, whilst on those days on which the samoom is not felt it varies between 53°.8 and 58°.8. Some travellers assert that when the samoom blows, the atmosphere takes a yellowish hue, frequently passing into the colour of lead; and that the sun appears dark-red whenever it blows with force. It is attended with a putrid and sulphureous smell, and the air appears to be thick and heavy, so as to excite the feeling of suffocation. It occasions a profuse perspiration, increased still further by the oppression felt on the chest, and by the difficulty of respiration. The perspiration itself is thicker and more adhesive than in common cases. It is even thought that the wind deposits a greasy fluid on the skin. If a person, for experiment's sake, inhales the wind, his palate and throat become instantly dried up. The same effects are experienced from inhaling it by the nose, but not so suddenly. To prevent this effect, and to render respiration more easy, the Arabs cover their faces with the *kafieh*—a handkerchief which they wear on their heads. In passing through the texture of this fabric the wind loses a part of its effect and of its noxious qualities. A certain degree of moisture is also imparted to the air between the kafieh and the mouth by the breath itself, which greatly facilitates respiration; and the burning air is prevented from penetrating suddenly into the mouth and lungs. The Arabs have also, generally, adopted the practice of enveloping their whole body, and even the head, in a large cloak when they lay down to sleep, whatever may be the degree of heat they have to endure. It is supposed that the samoom renders the blood less consistent, and that this produces a quicker circulation, the effects of which are felt in a rapidly increasing debility. It is certain that this wind, when it does not kill, always produces a great degree of exhaustion. Many persons, however, who are considered as being in a dying state, recover their health on discharging blood from the urinary vessels. As a peculiar fact, it is stated that the bodies of those who have been killed by the samoom undergo in a few days, and even hours, a peculiar kind of dissolution. A very small force is able to remove all the bones from their sockets. This is the statement of the Arabs, who consider such a corpse as contagious as the plague. During the wind, respiration is much relieved by strong vinegar being applied to the nose, and this is also said to diminish its noxious effects. Sometimes the samoom lasts for three days and three nights together, but not commonly. There are, however, instances in which it has continued to blow for seven days. Sometimes it is not experienced for a period of ten, and even fourteen, days; but the Arabs think that it has only changed its place, and is blowing in another part of the country. Formerly it was asserted that the hurtful effects of the wind could be avoided by a person throwing himself on the ground with the mouth downward; but modern writers say that the Arabs disapprove of such a proceeding, and perhaps justly, if it is true that the hot air by which the wind is attended is heavier than the atmosphere.

Section VIII.—Trade-Winds.

The seas by which our island is surrounded are under the influence of winds which frequently change their direction. They pass from one quarter of the compass to the other; and it is not a rare occurrence to find within three days, or even a shorter period, as many winds pass over our heads from opposite directions. It happens, indeed, that the wind sometimes blows continuously from one quarter for several days, or even weeks, but seldom oftener than once or twice a-year. It is also a well-known fact that at times the winds blow from different quarters at two places not very distant from one another, at the same time. Such being the case, it is evident that, except in very few and particular cases, nobody is able to foretell, with any degree of certainty, what wind we shall have to-morrow. But our winds do not only vary in direction—they vary still more in force. To-day a gale may blow, which occasions great havoc amongst our shipping, and strews the shores with fragments of vessels wrecked on rocks or lost at sea; and to-morrow it may lull into a calm which keeps the impatient navigator—returning to his country, and desirous to see his family and friends—nailed, as it were, to the spot. All degrees of winds—between a storm blowing with a force bordering on that of a hurricane, and the most perfect dead calm—may be experienced in the short period of twenty-four hours, and even in less time. This state of wind and weather is not peculiar to the sea contiguous to Great Britain. It extends on all sides to a great distance. Navigating the seas which lie to the east or west of our island, no change in this respect is observable even in their most remote recesses; and when we advance to the north, we find the winds always changing their direction and force, until our course is stopped by the icy masses which surround the Arctic Pole, and we have arrived at the utmost border of the known portion of the globe. But when we sail towards the equator, we arrive, after some time has elapsed, at regions where the wind always blows from the same quarter, or nearly so, and where its force is subject to very slight variations. We are then in the region of the trade-winds. Before we arrive at this region, however, we must pass through twenty degrees of latitude; and, after having made a voyage of about 1200 miles, we get to places where nature is subjected, in this respect as in many others, to a much more uniform and regular law than in our country.

The trade-winds are met with, as we approach the northern tropic, at a distance varying between four and eight degrees. The term *trade-winds* is of a doubtful origin and signification. Some think that it has been applied to these winds on account of their constancy, *trade* originally signifying a common *course* or *track*, the *course treaded;* and Hakluyt has the phrase, "the wind blowing trade," i. e. a regular course. Others think that it has been introduced by our seamen, because they considered these winds more favourable to the promoting of trade and commerce than any other wind they were acquainted with. Those who found the advantage of the perpetual winds, might entertain a certain degree of joy at finding that their toils were diminished and their voyages shortened. How different were the feelings of those who first experienced their effects! Christopher Columbus was the first who traversed the region of the trades in their whole extent, from the shores of Africa to the islands of the West Indies. He would have rendered his name immortal as the discoverer of the trade-winds, if he had not discovered America. The boldness with which he entered on this navigation, and the firmness with which he followed it up, show the capacity of his mind, and the extent of his genius and knowledge. As he had previously made several voyages to the Canaries, he had certainly acquired some knowledge respecting the direction and force of the trade-winds; but as these islands are only under their influence during a certain season, his information must have been far from being either correct or complete. Still he was not alarmed when he discovered that he was constantly sailing before the wind. It was otherwise with the crews of his vessels. At first they were well content at finding they were traversing a sea never agitated by a gale, and under the guidance of a wind always favourable, by which the laborious life of a sailor was converted into one of ease and comfort. But when after several days they became aware that the wind did not change, and was carrying them still farther from their own country, they began to fear that it would prevent them from ever returning to their homes. They then begged of their commander to turn back before they had got so far from home as to render it impossible to return for want of provisions. The great man was inexorable, and pursued his voyage. The wind still continuing to blow from the east, the crews became mutinous. They began to plot and to conspire, and at last to threaten their commander that they would throw him overboard if he persisted in advancing farther to the west. He was obliged to call into play the whole energy of his mind, the great authority he had obtained over his associates by his superior knowledge and talents, and his profound prudence, in order to obtain a respite of three days, under the promise that he would steer directly for Spain, if in this time no land should be found. On the third day an island was seen. Thus the trade-winds and America were discovered at the same time, and Columbus returned to Europe by traversing the region of the variable winds, which lies contiguous to the trades on the north.

The trade-wind in the Northern Atlantic is called the *north-east trade*, because the wind blows from that quarter, or from some point near it. It extends over the sea which lies north of the equator, to about 30° N. lat. But there occur some changes in its direction as well as in its extent, which are dependent on the position of the sun. When the sun has a southern declination, or in other words, when its perpendicular rays fall on the southern hemisphere, the wind inclines more to the north, and varies between north-east and north-north-east, but seldom blows from the northward of north-north-east. When the sun has a northern declination, or is in the northern hemisphere, the wind inclines more to east, blowing frequently from east-north-east, but rarely from the eastward of that point. This is the direction of the north-east trade-wind near the Old Continent, along the western shores of Africa. But in receding from these shores, and at a distance nearly equal between Africa and America, it becomes more easterly. It often blows from due east, and sometimes even from the south of east; but in general it is one or two points north of east, and from these points it continues to the islands of the West Indies. Captain Basil Hall differs somewhat from the account of other voyagers, stating that near the northern boundary-line, especially towards the Old Continent, the wind blows from due east, but soon declines gradually to the north-east, and eventually to the north-north-east; near its southern margin it turns even to the north.

The changes which occur respecting the extent of the sea and the parts of the ocean in which these winds blow are much greater, and, as far as we know, are entirely dependent on the position of the sun. When the sun has a southern declination, the trade-wind is not usually met with north of the Canaries, or north of 27° N. lat., but when the sun is in the northern hemisphere the trade-winds prevail as far north as 32° N. lat., so that its northern boundary varies through five degrees of latitude. The southern boundary of the north-east trade-wind in the Atlantic varies much more, according to the season of the year. In December, when the sun is near the southern tropic, and in the three following months, the trade-wind ceases to blow when the equator is approached to a distance varying between two and seven degrees, so that then its mean boundary may be fixed at five degrees from the line. When the sun has passed the equator in proceeding northward, the southern boundary of the north-east trade in the Atlantic recedes gradually farther to the north, and in the three months following the summer solstice the trade-winds cease to blow at a distance from the line which varies between 9° and 15° N. lat. Its mean boundary in these months may be fixed at 12° N. lat. Thus we find that the difference between the mean boundaries in the three months following the winter and summer solstice is not less than seven degrees of latitude. But when we take the extreme on both sides, we find that the difference amounts to thirteen degrees. Thus it is evident that in summer the north-east trade prevails over an extent of sea comprehending twenty degrees of latitude, and that in winter the seas subject to its sway extend over twenty-two degrees. These observations, however, are only applicable to the eastern parts of the Northern Atlantic, or those which lie near the African shores ; for on the side of America the trade-winds prevail all the year round to 30° N. lat.

This trade-wind is not very steady along its northern border, where it is sometimes interrupted by short calms, and at others by sudden puffs of wind. It is also, though rarely, replaced by a north-west wind, which blows with considerable force. The wind, however, is always found steady and regular when the northern tropic is approached from the north, and also between this tropic and its southern boundary. It blows with a gentle force, with what is called a *moderate* breeze, which propels a fast-sailing vessel at the rate of five or six knots per hour ; or with a *fresh* breeze, by means of which such a vessel may run seven or eight miles per hour. Vessels sailing before the trade make a hundred and twenty to a hundred and fifty miles a day ; therefore the region of the trade-winds affords a very safe and easy navigation. The vessel appears to descend a gently flowing river, and the sailors are exempt from the numerous toils with which the navigation of the region of the variable winds is attended. They have hardly ever to touch the sails and cordage. Even an open boat could venture to traverse the ocean in these parts. The Spaniards, when first navigating this sea, were so struck with the difference experienced in passing through the region of the trade-wind and the seas near Spain, that they called it the Sea of the Ladies, supposing that even ladies might muster courage enough to conduct a vessel through it, the more so as the variation of the temperature of the air between the night and day is so small that it hardly ever exceeds three degrees of Fahrenheit, and frequently not half that amount.

Persons who have gone to the West Indies in the track of the trade-winds, speak with rapture of this part of their voyage. They cannot enough praise the fine sunny weather, the fresh and pleasant eastern breeze, the clear blue canopy of heaven at night, lit up by the silvery moon and the effulgence of the stars. But nothing strikes their imagination more forcibly than the indescribable magnificence which is displayed before their eyes at sunset. The lower portion of the sky, almost from south-west to north-east, is overspread with a bright crimson ground, over which float light clouds in fairy forms of vapoury castles, islands, rocks, &c., of rich imperial purple, sombre, bronze, and brilliant golden hues. Above these fairy apparitions the crimson gradually fades into a delicate blush, which, near the zenith, mingles with the dark blue by which the sky of the intertropical zones is distinguished.

Vessels sailing from Europe to the West Indies and the countries which surround the Gulf of Mexico and the Caribbean Sea, commonly take advantage of the trade-winds. In the beginning of their voyage they do not try to make westing, but sail southward until they reach the region of these winds, passing the island of Madeira and the Canaries. Nor do they turn to the west immediately they have passed the last-mentioned group, because they know that in the sea lying west of them the trade-winds are still unsteady, and frequently interrupted by calms, light winds, and puffs. They continue, therefore, their course southerly until they have passed the tropics, when they turn westward, and steer directly to the place to which they are bound. Along this track a voyage from Cape Lizard to Kingston in Jamaica amounts to nearly 5000 sea miles. A vessel departing from Cape Lizard for Jamaica, and traversing the Atlantic obliquely, in a straight line between the two points, has only to make a voyage of about 3800 miles. The last track is shorter, therefore, by 1200 miles. Though along the last-mentioned track the vessel has frequently to contend with contrary winds, it has been ascertained that the voyage is commonly accomplished in a less time than that which lies across the whole extent of the trade-winds; so that probably the last-mentioned route will ultimately be entirely abandoned by vessels bound to the West Indies. This is not to be attributed to better information on this point, but to the high degree of perfection all branches of science and mechanic art have attained in our times, which refer to navigation. The advantages the region of the variable winds offer, may, by a skilful seaman, be turned to such an account as to enable him to accomplish the voyage in a straight line in a shorter time than he would have done if he had followed the track through the region of the trade-winds.

The north-east trade blows home to the very shores of the American continent, surrounding the islands of the West Indies; but it does not blow near the coast of the Old Continent, being there separated from them by a tract of sea in which westerly winds prevail. This tract extends to fifty miles or more off shore. This irregularity is to be ascribed to the effects which the hot desert of the Sahara produces in the atmosphere. The surface of this desert, which consists of loose sand and is almost without any trace of vegetation, is heated by the sun's rays to an excessive degree, and this has the effect of greatly rarefying the superincumbent air, and of rendering it less dense than the air which covers the sea contiguous to the desert. When, therefore, the air of the desert comes into contact with that of the sea, this latter rushes over the desert to re-establish the equilibrium of the atmosphere, and the current of air thus produced is the westerly wind, which is met everywhere along the African shores, as far south as the Cape Verde Islands. These shores have acquired a bad repute on account of the numerous shipwrecks which have happened there. This is partly to be ascribed to the westerly wind which blows directly in shore, but also to a current which runs along the shore southward, and at some places sets directly in shore, so that a vessel which is so unfortunate as to become entangled between this wind and the current, can hardly hope to make its escape, even by the most strenuous efforts of the crew.

When the navigator emerges from the region of the north-east trades, after passing their southern boundary, he enters *the region of the calms*. This region, like the trade-winds, does not occupy all the year round the same portion of the ocean, for it likewise follows the march of the sun, extending farther northward when the sun has a northern declination, and receding southward when it enters the southern hemisphere. We have seen already that its mean northern boundary in the month of the winter solstice lies at about 5° N. lat., and in those which follow the summer solstice at about 12° N. lat. Its southern mean boundary is always found to the north of the line. When the sun is in the northern hemisphere, it advances so far northward, that sometimes the south-east monsoon is found at a distance of 6° north of the line, and the parallel of 3° N. lat. may be considered as the southern boundary of the region of calms, for all the time from the month of May to that of October, including these months, or for half a year. Even in November and December the south-east wind is frequently met as far to the north. But in the four months following the winter solstice the southern boundary of the region of calms lies nearer the equator, in general only one degree north of it, and occasionally it recedes to one or even two degrees south of the line. During this period of the year the mean width of the region of calms extends over about four degrees, from 1° to 5° N. lat. In the three months succeeding the summer solstice it is much wider, as it occupies the whole region lying between 3° and 9° N. lat., or six degrees of latitude.

This region has received its name from the calms which generally prevail over its whole extent, but more especially along its northern margin. The dead calms, however, are frequently interrupted by light airs, which are hardly sufficient to give steerage-way. Occasionally very violent tornadoes or squalls are experienced, tearing away, in a moment, every rag of canvass from the ship's yards. Its climate is the reverse of that of the region of the trade-winds, the weather being damp, foggy, cloudy, and gloomy; and almost every day some sudden gusts of wind, accompanied by thunder and lightning, are experienced. For several hours at a time rain falls in absolute torrents. All these circumstances concur to render the navigation across this region extremely tedious and unpleasant. Even fast-sailing vessels cannot average more than thirty miles per day, frequently much less. There are instances on record of a vessel having been kept stationary for more than twenty-four hours, and even of its having lost a few miles of the progress it had made the day before. It takes a vessel commonly eight or ten days to get through this region, and it would take her still more if the trade-winds, by which it is enclosed on the north and south, did not frequently encroach on its outer border to a distance of about thirty miles from the boundary of the calms. It is, however, certain that vessels sailing to the north traverse the region of calms in a shorter time than those which cross it in a southern direction. This is to be ascribed to the direction of the light breezes, which frequently interrupt the calms, and commonly blow from the south or south-west, rarely from the north of west.

It is a very fortunate circumstance for the maritime intercourse between Europe and South America, that in summer the southern boundary of the region of calms lies 5° north of the equator, and that in the space between this boundary and the line a steady south-east monsoon is met with; for in this season the equatorial current runs with great force. This current flows from east to west along the equator, but more to the south than to the north of it, occupying generally a width of 5° of latitude. Its force in our winter months does not commonly exceed two knots per hour, and is frequently much less; but in July and August it runs at the rate of from three knots to three knots and a half. If this current was within the region of the calms, both together would almost form an insuperable barrier to the progress of vessels navigating these seas. Even at present, the equatorial current sometimes carries vessels sailing from Europe to South America out of their course. If a vessel bound on such a voyage crosses the equator to the west of 23° W. long., when the current runs with great force, it is frequently carried forcibly to the west beyond Cape St. Roque in Brazil, where it is driven towards the northern shores of Brazil; and when that takes place, weeks and even months of toilsome labour are required to bring the vessel back to its proper course.

The southern boundary of the region of calms is the northern boundary of the *south-east* trade-wind, which reaches southward, when the sun has a southern declination, to 30° S. lat., and in the opposite season to about 28° S. lat. Its sway therefore extends over a much greater space of the Atlantic than that of the north-east trade-wind. When the sun is in the southern hemisphere, the whole of the ocean between 1° N. lat. and 30° S. lat. is swept by this trade. Its width therefore is 31° of lat., or 9° more than that of the region of the north-east trade. Its mean width in the opposite season is not less, as then it extends from 3° N. lat. to 28° S. lat., whilst in this period of the year the north-east trade is only found to prevail over 20° of lat.

This wind in general blows from the south-east, but in this direction it undergoes greater changes than the north-east trade-wind. Along the western shores of Africa it blows from the south, declining frequently to the south-south-west, and even to the south-west. This remarkable change of direction is ascribed partly to the great elevation to which Southern Africa rises, and partly to the peculiar formation of the Bight of Benin. That the first circumstance exercises some influence on the direction of the wind is evident from its diminishing in force in proportion as we approach the shores of the continent. In its vicinity the wind dies away into calms, which frequently are interrupted by light airs, and sometimes by light and even fresh breezes. In receding from the continent, the wind gradually passes more to the east. The meridian of 10° W. of Greenwich may be considered as a line of separation between the winds which blow from the south and those from the east. To the east of that line the wind varies between south-west and south-south-east, and to the west of it between south-south-east and east-south-east. It hardly ever blows from due east, even near the American continent. Captain Basil Hall differs here from other navigators. According to his statement the south-east tràde blows, near the equator, from the south; but more to the south it declines to the south-east, and still farther on to east-south-east, until it reaches its southern margin, where it eventually blows from the east.

Along that border which looks towards the antarctic pole, this trade-wind, like the north-eastern, is frequently interrupted by calms, light breezes, and sudden gusts, but the variable winds hardly ever encroach on the region subject to its sway. Otherwise it is more regular, and blows with rather greater force than the north-east monsoon. It commonly blows with a fresh breeze, and sometimes freshens to a strong breeze, so that a fast-sailing vessel, sailing before the wind, may run from eight to ten knots per hour.

This trade-wind is very favourable to the vessels which return from the East Indies and from China. It is especially by its aid that these vessels commonly accomplish the voyage from the Cape to Cape Lizard in the short period of sixty days. It is, however, less favourable to those which are on their voyage from the British Channel to the Cape. Though its steadiness, and the force with which it blows, favour in a considerable degree the progress of the vessels, its blowing from the place to which their course is directed prevents them from making a rapid progress. At present, therefore, such vessels rather avoid opposing the wind. They sail, after having passed the line, near 23° W. long., along the shores of South America until they have reached the southern tropic, when they decline their course to the south-east, and soon enter the region of the variable winds, which here, as in the northern hemisphere, extends from the outer boundary of the south-east trade to the antarctic pole.

The progress of the vessels which follow this track is greatly promoted, for four or five months of the year, when the sun is in the southern hemisphere, by a wind which, along the shores of Brazil, and to a considerable distance from them, blows from between north-north-east and east. This wind owes its origin to the circumstance of the elevated table-land of Brazil, during the sun's stay in the southern hemisphere, acquiring a considerable degree of heat, which, by being communicated to the superincumbent air, produces such a rarefaction in the atmosphere, that the denser air which extends over the surface of the adjacent sea is continually advancing towards those parts of the South American continent where this rarefaction is going on, in the same manner as we have observed it before, when speaking of the effects of the Sahara in producing a wind contrary to the direction of the north-east trade-wind. This wind blows with the force of a moderate or strong breeze, like the trade-wind itself.

Such a great and marked difference between the trade-winds and the variable winds forcibly struck the scientific men who had applied their minds to the task of explaining the phenomena, and they began to account for their origin by appealing to the laws of nature as far as they were known at the time. It was first considered that the trade-winds owed their origin to the revolutions of the earth round its axis, and to the circumstance that the atmosphere, though it participated in that motion, could not follow with equal speed the motion of the denser parts of our globe.

This of course must produce a current in the air having a contrary direction to that of the earth round its axis, and moving from east to west. The strongest proof which could be produced in support of this explanation was the circumstance that the trade-winds occur only in the lower latitudes, where the surface of the earth, in its revolution round its axis, has to make a large circle in twenty-four hours, and consequently must move with a greater degree of rapidity than in the higher latitudes. This explanation originated with the Italian philosopher Galileo; but our countryman Halley, having collected more exact information respecting these winds, pointed out several facts which were incompatible with the opinion of Galileo. The two most decisive points were, that there are no trade-winds contiguous to the equator on the northern side, where the diurnal motion of the earth is much greater than at many other places where trade-winds are met with; and next, that the trade-winds change their position according to the seasons, which could not take place if they were only the effect of the rotation of the earth. He proposed therefore another explanation of these phenomena. His theory rests on the well-established principle that wind is only a current of the air, or a part of our atmosphere in a state of more or less rapid motion, and that its principal cause is a partial or local rarefaction of the air by heat. When the air at a place is heated, it strives to occupy a larger space; and as at the same moment it has become lighter, it is enabled to rise higher into the atmosphere. If, under such circumstances, the air superincumbent on a contiguous place is not heated to the same degree, it preserves a greater density, and this less rarefied or colder air rushes into the place occupied by the lighter air to restore the equilibrium. The current of air thus produced is what is called a wind. Supported by this principle, Halley ascribes the origin of the trade-winds to the rarefaction produced in our atmosphere by the apparent diurnal progress of the sun. It appears that the heat caused by the sun in the air is strong enough to produce this rarefaction to an extent of about 60° of latitude, as the trade-winds, including the region of calms, extend over such a portion of the globe. In this immense space the rarefied air is replaced by the colder and denser air which rests over the region contiguous to the region of the trade-winds, and this transportation of air is the trade-wind. As the difference of the density of the two portions of air which are brought into contact with one another is not great, the wind is of moderate force.

To this theory of Halley an objection is made by Hadley. He says that rarefaction alone cannot be the cause of the trade-winds, as in that case the air would rush in from all sides to that place where the rarefaction was greatest, and especially so from the north and south, where the air is certainly much cooler and denser. The wind, therefore, cannot blow from the east. The coolest portion of the atmosphere lying before the progress of the sun is, on the north of the line, certainly in the north-west; and that lying behind its course is in the north-east. Therefore rarefaction must, on the north of the equator, produce a north-west wind in the morning and a north-east wind in the afternoon. In the southern hemisphere, the sun would be preceded by a south-west wind, and it would be followed by a south-east wind.

It appears, however, that in laying down this principle, Hadley did not bear in mind, that by the effect of the sun's rays the air superincumbent on the intertropical regions, as also the sea and land, is heated to such a degree that the variation of temperature in twenty-four hours does not amount to more than a degree, or a degree and a half; that the air of the temperate region adjacent the tropics is nearly as much heated, and that the variation of temperature is not much greater; but that in retiring farther from the tropics to the north and south, the air gets cooler in proportion to the distance from them. In such circumstances the air must always flow gently from the south and north towards the intertropical countries; and the rarefaction can only produce a hardly perceptible increase of the wind, the air being supplied by the region adjacent to that in which the greatest rarefaction takes place, which in the northern hemisphere is placed to the north, and in the southern to the south, of the intertropical countries.

Mr. Dalton, who adopts the theory of Hadley, makes another objection to that of Halley, saying—"Had the trade-winds been produced by the daily rarefaction of the air alone, independent of the earth's rotation, they should have extended to 50° N. lat. when the sun is in the tropic of Cancer, because the heat at that parallel is then as great as at 30° of S. latitude; in fact, they ought to have extended in a greater or less degree over the ocean from the equator to the poles, and the summers have been more tempestuous than the winters, because the daily variation in heat is then greatest." So it certainly would be, if the counter-current in the upper regions of the atmosphere, of which we shall speak presently, did not exist. But the air of this counter-current, when it arrives at the outer boundaries of the trade-winds, has been cooled and condensed to such a degree, that it is enabled to press down to the surface of the globe, and to change entirely the direction of the wind.

It appears that the greatest objection to the adoption of the theory of Halley is the circumstance, that the trade-winds do not blow from due north and south, but from north-east and south-east. This phenomenon may perhaps be explained in the following way:—If the wind could flow with a degree of velocity equal to the progress of the sun, it would blow from due north on the northern side of the places which are under the influence of the perpendicular rays of the sun, and from due south on the southern side of such places. But the velocity of the aërial current is infinitely less than that of the earth. Hence it follows, that the wind has hardly taken the direction which is imparted to it by the rarefaction of one place, when the place of the greatest rarefaction has already changed, having proceeded farther west. This causes the wind to decline to the place of the greatest rarefaction, and thus the northern wind is converted into a north-eastern and the southern into a south-eastern wind. When we further consider that this progress in the atmosphere is rapidly extending westward—if not interrupted by the intervention of the land—we easily conceive how the quick progress of the rarefaction towards the west insensibly influences still more the direction of the wind, and hence it is found that in the western portion of the Atlantic the trade-wind blows nearly from due east. Where the trade-wind does not exactly follow this course, its direction has been disturbed by the localities of the adjacent continents, as we have mentioned in speaking of the effects of the Sahara, the high land of Africa, and the table-land of Brazil.

George Hadley, the brother of the inventor of the quadrant, proposed another theory, which for a long time was neglected and overlooked, but lately has been brought forward by Dalton and Daniell. It is a partial revival of the theory of Galileo. He supposes, as Halley does, that there exists a continual flow of air from both the north and south towards the equator; that in the neighbourhood of the poles, and as far from them as the polar boundaries of the trade-winds, the pressure of the air is sufficient to keep it firmly fixed to the places on which it rests, so that no regular current to the west is formed; but that in the tract where the trade-winds are formed, the rotatory velocity of the earth is so great, that the pressure of the air is not sufficient to keep it in its position, and that within the region of the trade-winds the earth moves with greater velocity than the superincumbent air, which difference of motion produces the trade-winds. "The two general masses of air," says Dalton, "proceeding from both hemispheres towards the equator, as they advance are constantly deflected more and more towards the east on account of the earth's rotation; that from the northern hemisphere, originally a north wind, is made to veer more and more towards the east, and that of the southern hemisphere in like manner to veer from the southward towards the east: these two masses meeting about the equator, or in the torrid zone, their velocities north and south destroy each other, and they proceed afterwards with their common velocity from east to west round the torrid zone, excepting the irregularities produced by the continents."

A theory conceived for the explanation of a natural phenomenon can only be called perfect when all the peculiarities by which the phenomenon is attended can be explained according to the known laws of nature. That theory which explains the greater number of these peculiarities is nearest the truth. Examining the theories of Halley and Hadley on this principle, we must give the preference to the former, as it accounts for all peculiarities of the trade-winds in a satisfactory way, with the exception of the region of the calms, and its peculiar nature. The theory of Hadley assigns no reason for the change of the position of the trade-winds according to the seasons ; nor for the difference in their direction near the Old and New Continents. Neither does it explain why, in those places of the globe where the rotatory velocity of the earth is greatest, no constant current of air is met with.

Halley, according to the principles above explained, supposed that the heated and rarefied air rises above the more dense portion of the atmosphere ; and when it has arrived at a certain elevation above the surface of the globe, it is condensed by the cold which there always prevails, and is thus enabled to sink again lower down. But being unable to return to its former plane, which has been occupied by a colder and denser air, it flows off towards the poles, or rather towards those parts which have supplied the air to the rarefied plane. This expanse of the upper air takes a direction quite opposed to that of the trade-winds, namely, to the north-west, from which quarter the greater part of the air had been derived which occupied their place within the region of the trade-winds. Thus two currents of air are found within the trade-winds ; of which the lower flows to the south-west north of the line, and to the north-west south of it, whilst the upper currents run in the opposite directions. As by their longer stay in the more elevated regions of the atmosphere these upper currents become more and more condensed, they by degrees acquire a density which enables them to descend to the surface of the globe, which, however, only takes place when they have arrived beyond the outer boundary lines of the trade-winds. To this process of nature it is ascribed that within the region of the variable winds those which blow from the south-west in the northern, and from the north-west in the southern hemisphere, have a considerable preponderance over those which blow from other quarters. This last circumstance certainly is in favour of the existence of two upper currents, but still it was considered only as a theory, which required to be confirmed by facts, until in 1812 an event occurred which established at once its solidity. In the eruption of the volcano of St. Vincent, considerable quantities of ashes and other volcanic matter descended on, and spread over, the island of Barbadoes. This event excited, at that time, a high degree of surprise, as in this part of the Columbian Sea the trade-wind always blows with considerable force, so that vessels sailing from St. Vincent to Barbadoes are obliged to make a circuitous course of some hundred miles to reach the place of their destination. The ashes, therefore, had been carried against the prevailing wind. It can hardly be questioned that the volcanic matter was raised by the eruption of the volcano to such an elevation that it reached the counter-current, which, blowing from the west, carried it to Barbadoes.

As the Pacific Ocean is at least three times as large as the Atlantic, it was supposed that the laws of nature had there a less impeded sway, and that consequently the trade-winds must be there much more regular than in the seas between Africa and America. This supposition received some support from the accounts of the navigators who visited the Pacific in the last century. But by the numerous voyages which have been made in those seas since the beginning of this century, our information respecting them has been greatly increased, and it tends by no means to confirm the opinion which had been formerly conceived respecting the trade-winds in this ocean. On the contrary, it appears that hardly one-half of the Pacific, which according to the former opinion should be continually swept by the trade-winds, is under their uninterrupted influence.

As to the boundaries of the two trade-winds, it does not appear that there is any considerable difference between the Pacific and the Atlantic, at least not as regards the southern boundary of the south-east and the northern boundary of the north-east winds. The first lies, when the sun is in the southern hemisphere, between 30° and 31° S. lat., and when it has a northern declination near 25° S. lat. The northern boundary of the north-east trade is also found to vary between 26° and 30°. But where the two boundaries lie which divide the trade-winds from the region of calms has not yet been ascertained, as the accounts offer considerable anomalies, which cannot yet be reconciled. It is however certain, that here too the region of calms is found north of the equator, but perhaps at a mean not more than three or four degrees, and that it sometimes extends to twelve degrees and more from the line northward.

But in the Pacific the trade-winds do not approach so near the western coasts of America, as in the Atlantic to those of Africa. Along the shores of South America a southern wind always blows, and this wind extends to a distance of from four hundred to five hundred miles from the continent. Beyond that distance a steady regular trade-wind is met with, which near the equator blows from south-east, but farther south gradually declines to east, and even east-north-east. It is very probable that the high mountain-masses of the Andes prevent the south-east trade from approaching nearer the continent of South America. Still greater is the space which separates the north-east trade from the shores of Mexico and Central America. Here the regular winds are only found at a distance of from six to seven hundred miles from the coast, from the beginning of May to the end of December, and during this period western and south-western winds prevail in the northern, and north-westerly winds in the southern, portions of this large tract of sea.

With the last-mentioned exception, the whole sea between America and the eastern shores of the island of Formosa and of China is under the regular sway of the north-east trade, which is only interrupted by the Ladrones, a group of islands extending north and south over more than seven degrees, and on the west of which south-western and western winds are prevalent, at least during the period that the sun has a northern declination. The group of the Sandwich Islands lies in the direction of the trade-winds, and does not interrupt their course further than that, in the immediate vicinity of them, the daily alternation of sea and land breezes is experienced.

The south-east trade-wind, however, if considered as a regular perpetual wind, traverses only over the smaller portion of that region which should be under its dominion, and this lies towards the American continent, between 90° and 140° W. long. The sea which lies west of 140° W. long. is as it were dotted with groups of islands or isolated islets. In this region the trade-wind seems to be converted into a monsoon, that is, a wind which during one-half of the year blows from one direction, and the other half from the opposite one. We owe the first observation on this anomaly of the south-east trade-wind to Captain Fitzroy, who in speaking of the Paamuto Islands, or the Dangerous Archipelago of the Low Islands, observes that among them a steady south-easterly trade-wind prevails only from March to October, but that when the sun is in the southern hemisphere, westerly winds, squalls, and rains are frequent. Later accounts give us much more exact information respecting these changes. It has now been ascertained that a westerly or north-westerly monsoon blows with steadiness, force, and great regularity along the northern shores of New Guinea, at New Britain, New Ireland, and all the contiguous islands south of the equator as far westward as Rotumah (178° E. long.). It continues eastward to the Society Islands and the Marquesas, but decreasing gradually in strength and steadiness. This monsoon commences blowing with force in December or January, is attended in February with squalls and heavy rain, and in April and May is replaced by variable winds. In June the south-east trade or monsoon sets in strongly with heavy rains and squalls, and continues so until the end of August. In September the strength of the south-east monsoon—for so it must be named on account of the rainy weather with which it is attended—is spent, and the weather is more moderate from this time until the return of the north-west monsoon. These monsoons are met with in the Pacific from 1° N. lat. and 15° S. lat., and occasionally so far south as 19° S. lat.; but their mean southern boundary may be fixed at 13° S. lat. They change their character, however, east of the island of Rotumah. The westerly monsoon is less constant, but blows with force for seventeen or eighteen days, when it abates, and is soon replaced by an easterly wind, which blows with a fresh breeze for nearly the same period; when westerly winds again commence, usually beginning with a gale, and always continuing with a strong breeze, with squalls and rain. Thus the easterly and westerly winds blow alternately from December to the end of March, when the south-east trade sets in with steadiness and fine weather.

In this manner the south-east trade is replaced by monsoons in the western seas of the Southern Pacific. It is somewhat difficult to account for this apparent anomaly; but all circumstances appear to prove that we must look for the cause of these changes to the almost innumerable islands and coral rocks which cover this part of the ocean, and some clue to the solution of the question may be found in the observations of an attentive observer (Horsburgh), who says that " where shoal coral banks shoot up out of the deep water, in many places between the tropics, a decrease of the prevailing wind is frequently experienced. For when a steady wind is blowing over the surface of the deep water, no sooner does a ship get upon the verge of a shoal coral bank than a sudden decrease of the wind is often perceived. This is occasioned by the atmosphere over these banks being less rarefied by the increased evaporation than that over the deep water, and consequently not requiring so great a supply of air to restore the equilibrium as the adjacent parts, which are more heated and rarefied." When a single coral bank, lying in the way of a trade-wind which has blown regularly over an extent of many hundred miles, is thus able to cause a very perceptible decrease in the strength of the wind, we may easily comprehend that their great number and extent in the Southern Pacific is able not only to change slightly the direction of the wind, but even to turn it to the opposite quarter, and thus to exercise an influence on the state of the atmosphere, nearly, if not entirely, equal to that of a large continent.

The discovery of this monsoon has at once set to rest a question which for a long time had puzzled the heads of men. When most of these islands were discovered, the very curious fact was ascertained at the same time that its inhabitants belonged to the Malay race. The conformation of their bodies, their language, and a great number of their usages, showed such a similarity to those of the Malays, that not the least doubt remained on the minds of those who had an opportunity of becoming acquainted with these nations as regarded their origin. Now it was already known that the islands of Sumatra and Java, together with the Malay peninsula, must be considered as the true native places of this race, and that they had spread from these places over the adjacent islands. Moreover, there were good reasons for the supposition that the inhabitants of the islands of the Pacific had arrived there by advancing from west to east. But how was such a migration to be comprehended, when it could only be effected by navigating in open boats against a constant trade-wind which blows with considerable force? At present, it is evident that the same north-west monsoon which carried the Malays to the Moluccas, has opened them the road to the Viji, Friendly, and Society Islands, and that this nation has thus been enabled to take possession even of the most eastern of the Paamuto Islands.

The trade-winds are not only met with on the sea.

Countries of great extent are found, on both continents, in which they prevail. But such countries must not be raised much above the sea-level, and must besides have a level surface, where nothing occurs that can break the force of the wind or change its direction. For if the wind comes in contact with high land or mountains, its regular progress is obstructed, and its course deflected into a different direction. Over a considerable tract of low land, however, the wind passes without being much changed in its direction and velocity, particularly if the land be barren and destitute of moisture. The largest of such plains is the Sahara, or Great Desert of Africa, where a strong eastern wind always prevails, which in daytime frequently increases to a gale, but towards evening abates, and at night mostly lulls into a dead calm. In the eastern districts of the desert, the surface of which is more diversified by depressions and eminences, and at some places by short and low rocky ridges, the wind is less constant, and blows with less violence. An easterly wind passes also, almost without interruption, over the woody plain drained by the river Amazonas. By its assistance the voyage against the strong current of the river may be accomplished in nearly the same time as the voyage downwards by means of the current. This wind is moderate near the mouth of the river, but increases in strength in proportion as it ascends, and at the base of the Andes has acquired such force, that it is almost impossible to keep one's footing against it. A similar easterly wind, though of less strength, is nearly always sweeping over the vast and treeless plain traversed by the lower course of the Orinoco.

Section IX.—Monsoons.

The trade-winds, as we have seen, blow the whole year round from the same quarter. Though they facilitate the navigation of those seas in which they are found, they do it only in one direction, and greatly retard the progress of vessels which have to pursue the opposite course. A vessel bearing up against the trades can only advance by tacking, and then but slowly. Such vessels, therefore, try to avoid the wind, where it is possible, by a circuitous route, and through seas where variable winds prevail. This, however, would, in most cases, carry them too far out of the direct course. They prefer therefore, to sail, by the assistance of the trade-winds, either to the north or south, and continue in such a direction for several hundred miles, until they think that they have arrived at a place from which, by another tack, they can fetch the port to which they are bound. It is easy to conceive that such voyages must be extremely tedious, which is also confirmed by the great difference of time in which the out-voyages and the return-voyages are performed between two places lying east and west of one another, and within the influence of the trade-winds. For instance, ships which leave Jamaica, and are bound to the Virgin Islands, Antigua, or St. Kitts, take several weeks to accomplish the voyage, whilst they return from the last-mentioned place to Jamaica in a few days. The navigation between the different islands of the Canaries is attended with the same circumstances. During the prevalence of the trade-winds in these seas a vessel can run from Teneriffe to Hierro in less than one day, but to return from Hierro to Teneriffe generally takes ten or twelve days, and sometimes even three or four weeks.

But winds prevail in another part of the ocean which are much more favourable to navigation. These winds blow for six months of the year in one direction, and for the other six in an opposite course. They are, therefore, called periodical winds. They are almost entirely limited to the northern part of the Indian Ocean. Most of the countries and islands surrounded by the sea in which they prevail are inhabited by Malays. In the language of these people they are called *mooseen*, a term which properly signifies year or season. This term has been received into the English language in the corrupted form *monsoons*.

The monsoons do not sweep over the whole of the Indian Ocean. In its most southern parts variable winds prevail, which are met with in the seas extending from the antarctic pole as far north as 28° or 29° S. lat. North of this parallel the sea is subject to the south-east trade; which, however, in the Indian Ocean sweeps over a much smaller extent of sea than in the Atlantic or Pacific Ocean. In the Indian seas it does not usually reach farther north than 13° or 12° S. lat., though occasionally it advances to 10° S. lat. The parallel of 12° S. lat. may be considered as the mean northern boundary of the south-east trade in the Indian Ocean.

This parallel is the southern boundary of the monsoons, which hence rule over the whole ocean to its most northern recesses. Before we enter into a detailed account of these winds, and the peculiarities with which they are attended, it must be noticed that at no season of the year is the whole extent of the sea under the sway of one monsoon, but that all the year round two monsoons are sweeping its surface. They blow from different, but not opposite quarters. It must not, however, be imagined that both monsoons prevail on the same portion of the sea at the same time, either alternately or otherwise, but that one of them sweeps one portion of it, whilst the other is subject to another monsoon. The line which separates the two monsoons blowing at the same time lies near the equator, and this great circle may, therefore, be considered as their common boundary. As those monsoons which prevail north of the equator have most attracted the attention of Europeans, on account of the great influence they exercise on their commercial intercourse with India and China, it seems advisable to take notice of them first.

On the north of the equator the Indian Ocean consists of three large gulfs, which, proceeding from west to east, are called the Arabian Sea, the Bengal Sea, or Gulf of Bengal, and the Chinese Sea. In these three seas a north-eastern wind prevails when the sun has a southern declination, or from October to April; and a south-western wind when the sun's perpendicular rays fall on the northern hemisphere, from April to October. The first is called the north-east, and the second the south-west monsoon.

It is not quite correct to say that either of these monsoons blows for six months. They hardly anywhere prevail for more than five months, and there are two months of the year in which no monsoon is met with in the Indian Ocean, namely, from the middle of March to the middle of April, and from the middle of September to the middle of October. At these periods the changes of the monsoons are effected. At some places it occurs a week or two sooner, and at others later. When one of the monsoons is about to cease, the winds grow gradually weaker, and are occasionally replaced by calms. The atmosphere, even on the sea, begins to be in a disturbed state, the air becoming sultry, heavy, and foggy, and the sky overcast. The winds also frequently change the quarter from which they blow, and are accompanied with gales, hurricanes, thunder-storms, and rains. After this state of the atmosphere has continued for three or four weeks, the weather changes, and the other monsoon sets in. It is certainly a remarkable but well-established fact, that as soon as one of the monsoons ceases, the clouds in the upper region of the atmosphere take the direction of the opposite monsoon, though several weeks must pass before this monsoon descends to the lower strata of the atmosphere, and becomes prevalent on the surface of the sea.

The *north-east* blows from November to March. It extends at some places to one or two degrees south of the equator, and blows with the greatest regularity and force in the Arabian Sea. Along the eastern shores of Africa it becomes sooner settled than in the middle of the sea, and near the equator sooner than at Cape Guardafui and along the coasts of Arabia. It blows in this sea with the greatest force in the month of January, and is most violent in the northern parts, especially between the island of Socotra and Bombay. When steam-navigation was introduced in India, the first steamer which left Bombay for the Red Sea found the wind so violent, and received such damage, that she was obliged to return to Bombay. This monsoon does not bring rain to the countries surrounding the Arabian Sea on the east and north, but during its prevalence the eastern shores of Africa have their wet season, rain falling abundantly from the beginning of November to the end of March. It must, however, be observed, as an ascertained fact, that the monsoons do not bring rain in themselves, as not a drop of rain commonly falls on the sea during their prevalence; but no sooner does the monsoon reach the shores of a country than the rain pours down.

In the Bay of Bengal the north-east monsoon makes its appearance somewhat later. It does not regularly set in, nor does it blow with force, before the beginning of December, when it blows from east-north-east or north-north-east. In January it is commonly subject to irregularity in strength, and frequently declines to south-east. In March it ceases entirely in the centre of the gulf, where it is commonly replaced by calms and some light variable winds. In the north-eastern parts of the gulf, and along its shores, it then blows faintly, with long intervals of calms. Though this monsoon in the Gulf of Bengal remains unsettled till December, it is preceded for five or six weeks by heavy squalls and winds in the southern parts of the sea, especially along the coast of Coromandel; and it is during these squalls that this part of Hindustan is fertilized by abundant rains.

In the Chinese Sea, and those parts of the Indian Ocean which are immediately connected with it, the north-east monsoon is also subject to some irregularities. It blows there with more uniform strength than in the Gulf of Bengal; but its direction undergoes many changes, which are to be ascribed chiefly to the direction of the coast which surrounds the Chinese Sea. In the sea which separates the Philippine Islands from China it blows regularly from the north-east, but in the Bay of Tonquin it declines to the north-north-east, and along the coasts of Cochin-China it proceeds from due east; whilst in the Gulf of Siam it comes from the north from November to January, but during the remainder of its prevalence declines more to east. This monsoon brings rain to all the countries which enclose the Chinese Sea on the west and south. Where the winds blow directly in-shore, as they do with Cochin-China Proper and the northern coasts of Borneo, the rains are very abundant. A trust-worthy traveller states that during his stay at Turon Bay, in Cochin-China, the rains were so abundant and incessant for more than twenty-four hours, that the surface of the sea was covered with a stratum of fresh water, which was found good enough for culinary purposes; and the casks of his vessel were filled with it.

The *south-west* monsoon does not reach the equator, but is usually met with at a short distance north of the line. It blows from the middle of April to the end of September. Like the other monsoon, it is most regular, and blows with the greatest force, in the Arabian Sea. Along the coast of Africa, being influenced by the trending of the shores, it blows from south-south-west, and there it makes its appearance as early as the end of March, but along the western shores of Hindustan it is not met with before the 12th of April. Along the shores of the last-named country it advances gradually from south to north, setting in sooner on the coasts of Travancore and Malabar than on those of Canara and Concan. At Anjengo (8° 30′ N. lat.) it sets regularly in on the 12th of April, but at Bombay (19° N. lat.) not before the 15th of May, so that its progress extends only at the rate of one degree of latitude in about three days. It reaches the coasts of Arabia and Beloochistan still later. This monsoon brings rain to the western shores of Hindustan. The rains are very abundant in the southern districts, but decrease gradually in proceeding farther north. At Tellicherry (12° N. lat.) the annual quantity of rain amounts to 116 inches, but at Bombay it does not exceed 63 inches ; and the delta of the Indus probably has not more rain than the vicinity of London (20 inches).

In the Bay of Bengal the south-west monsoon is more regular in strength than the north-east monsoon, but varies more in direction ; for it blows frequently from the south and even from the south-east, especially near the mouths of the Ganges. Hardly any rain falls during the prevalence of this wind on the western shores of the Bengal Sea, but there are very abundant rains on the northern and eastern shores. These rains fertilize the great plain of Bengal by raising the waters of the Ganges above its banks, and laying under water an immense tract of country. They extend over the plain to the very base and even over the lower declivities of the Himalaya Mountains, and along this range as far north as the point whence the Ganges issues from the mountains. But the quantity decreases as the rain advances farther northward. The annual quantity of rain at Calcutta is 72 inches, but at Benares not more than 46 inches fall annually, and still less in the level country which extends farther to the north and west. The greatest quantity of rain, however, appears to fall on those countries which enclose the Bay of Bengal on the east, especially on those adjacent to its northern parts, in Chittagong and Aracan, where, according to a rough estimate founded on partial observations, the annual amount of rain is not less than 200 inches.

In the Chinese Sea the south-west monsoon hangs more to the south than the west, blowing in general from south-south-west. Its strength is considerable, and it is never interrupted with calms, except near the equator, but is sometimes accompanied by high winds. In this sea, too, this monsoon brings rain to all the countries lying to the north and east of it. In the Philippine Islands, and along the southern shores of China, the rainy season sets in about the beginning of May, and continues to the end of September or the beginning of October. These rains must be called abundant, when compared with the quantity which falls on the countries without the tropics; but they are scanty, when put in comparison with those of Bengal, the coast of Malabar, or Chittagong.

It is not possible to determine exactly the place where the north-east monsoon terminates on the side of the Pacific, as in these parts its direction does not materially differ from the trade-wind which sweeps over the northern portion of that ocean. But as the south-west monsoon blows in an opposite direction, it is clear that there must be a place where it terminates, and where the trade-wind begins. Some authors are of opinion that the monsoon extends as far north as Kiusiu, the most southern of the Japanese islands, but it appears that it does not reach so far, and that it ceases to blow near 27° N. lat. A similar disagreement exists respecting its eastern boundary. Most authors maintain, that in that direction it extends to the Ladrones. They rest their opinion on the circumstance that west of these islands the western and south-western winds prevail in summer; but it appears that this wind has no connexion with the monsoon, as in these oceans, between the Ladrones and Philippines, a tract of sea occurs several degrees in width, where the eastern trade-wind is met with all the year round. According to the greater number of facts which we have for determining this point, it would seem that the eastern boundary of the south-west monsoon must be fixed near the meridian of 136° E. of Greenwich.

As soon as the peculiar nature of these extraordinary winds was known, and the phenomena by which they are attended, an explanation of their origin was sought for and tested. It appeared that this explanation could not be founded on a firmer base than by resting it on the same principles by the application of which Halley had succeeded in explaining in a satisfactory way the origin of the trade-winds. For this purpose it was pointed out, that the Indian Ocean differs greatly from all other large portions of the sea lying within the tropics, as it is on all sides surrounded by land, except on the south-west. Though there is a large open space of sea between the eastern coast of Africa and the island of Madagascar on one side and the north-western shore of Australia on the other, yet these countries, consisting mostly of sandy desert, must greatly affect the state of the atmosphere when their surface is heated to a great degree by the long stay of the perpendicular rays of the sun. Hence it seems to follow, that when the sun is in the southern hemisphere, and has heated the sandy plains of Australia and Africa, the air superincumbent on these countries is so rarefied as to rise into the higher regions, and thus the colder air, which in that season envelops the northern hemisphere, rushes southward to re-establish the equilibrium of the atmosphere. This current of air is the north-east monsoon of the Indian Sea. This explanation is satisfactory, as it is not at variance with the phenomena with which the wind is attended. It receives, on the contrary, a strong support from the gradual progress of the wind from south to north. For it is evident that, as the rarefaction of the air is first effected in the southern parts of the ocean, the current must first become perceptible there, and only when it continues longer, and increases gradually, is the more distant air called in to supply the deficiency. Therefore the north-east monsoon begins near the equator and extends gradually northward to Cape Guardafui and the shores of Arabia.

The same principles were applied to explain the origin of the south-west monsoon. Along the northern tropic, and on both sides of it, countries are found which form a part of the continent of Asia, and here, too, are large plains, some of which have a sandy soil and are subject to be heated to a great degree when under the influence of the perpendicular rays of the sun. Under such circumstances a considerable rarefaction of the air must take place, and the consequence is, that the southern air, which is only heated by the oblique rays of the sun, and consequently much colder, flows northward to replace the air which has escaped by rarefaction. We must now observe, that this explanation is not in accordance with the phenomena. If the rarefaction of the air, which is the supposed cause of the wind, takes place near the tropic, it follows, as a matter of course, that the wind must make its first appearance near the tropic. It does not; but it appears to arise, first, in those tracts of the sea which lie near the equator. Further, we should expect that the wind would extend gradually from the place of rarefaction to those parts of the sea which are contiguous to the line. It does not; but it advances from the equator to the tropic, or to the place where, according to the hypothesis, the rarefaction of the air occurs. At Anjengo, as we observed, it is felt more than a month sooner than at Bombay. It may, perhaps, be objected, that the effect takes place immediately after the sun, in its progress to the northern hemisphere, has crossed the equator, and consequently there the wind must first make its appearance. But to this we answer, that the sun at that time must rarefy the air near the line, and that, according to our knowledge of the constitution of our atmosphere, the wind should continue to blow from the north, as at that time the air incumbent on the northern hemisphere, having been deprived of the perpendicular rays of the sun for six months, must certainly be much colder than that of the southern hemisphere, which has been exposed to the sun's full force for half a year. An hypothesis at variance with all the phenomena it attempts to explain cannot be admitted. It would therefore appear that our knowledge of the laws of nature is still too incomplete to afford a satisfactory explanation of the origin of the south-west monsoon. We shall only observe, that the wind closely accompanies the sun in its progress, or rather precedes its march. On the 21st of April the sun has advanced twelve degrees from the equator, and on the

12th of that month the wind invariably sets in at Anjengo. On the 21st of May the perpendicular rays of the sun fall on the parallel of 20° of northern latitude, and on the 15th of that month the wind sets in at Bombay.

We pass to the monsoons which prevail in the Indian Sea south of the equator. Their southern boundary, as already observed, lies between 12° and 13° S. lat., and as on the north they frequently are met with at a distance of one or two degrees north of the equator, their northern boundary may be fixed at 1° N. lat. In the region confined by these two lines a south-eastern wind prevails when the sun has a northern declination, from April to October, and a north-western when it is in the southern hemisphere, from October to April. Here, too, the change of the monsoons takes place during a space of from three to four weeks, at which time the air is in a very unsettled state, and alternately subject to gales, hurricanes, variable winds, and calms.

The *south-east* monsoon blows commonly from that quarter whence its name is derived, but as the long chain of islands, of which Java is the largest, lies in the middle of the region, and extends nearly due east and west, the monsoon takes also that direction in this part of the sea, and hence it is called by some the east monsoon. In that part of the Indian Ocean which lies between the northern shores of Australia and the equator, this monsoon blows with great regularity and considerable force, but west of Sunda Strait it is frequently weak, and sometimes interrupted by other winds. It is a remarkable fact, that this monsoon is never attended with heavy and lasting rain, as the others are, though during its prevalence smart showers are rather frequent at many places, and perhaps everywhere. But in general the weather is comparatively fair and settled.

The *north-west* monsoon prevails from November to the end of April. In the sea between Madagascar and Sunda Strait it varies in direction between north-west and south-west, and is there in general not very regular in strength, except in December and January, when it blows with force. In the Java Sea—as that part of the

Indian Ocean is called which lies north of Java and extends eastward to the island of Timor—and in the Molucca Sea, which lies between Timor on the west and New Guinea on the east, this wind commonly blows from due west; hence it is frequently called the western monsoon. In these seas, and also south of them to the shores of Australia, it is regular, and blows with considerable force. This wind brings the rainy season to all countries to which its influence extends; and though the quantity of rain is not so great as in some countries subject to the south-west monsoon, it is rather abundant even for countries lying between the tropics. These rains appear to fall in greatest abundance on the northern shores of Australia, where the seasons resemble those of Hindustan, as far as their constancy is regarded. For during the months of June, July, August and September not a drop of rain falls; whilst in the other months, especially in December and January, the rains are very heavy, though perhaps not quite so heavy as in many places in Hindustan.

The south-east monsoon is considered as a continuation of the trade-wind of the Southern Pacific. There is certainly a great resemblance between them in character, both being serene, and very rarely, if ever, attended with heavy rains. Besides, we know than in the season when this monsoon prevails, the south-east trade-wind extends over the whole breadth of the Pacific to the very shores of Australia and New Guinea. Considering this monsoon as a continuation of the trade-wind, its origin does not require an explanation.

The north-west or west monsoon, however, which in almost all its phenomena differs greatly from the trade-winds, would certainly claim an explanation of its origin, but hitherto no hypothesis has been offered for that purpose. This apparent neglect is partly to be ascribed to the difficulty of the task, and partly to the circumstance that this monsoon was considered to occupy in the Indian Ocean, the place which in the Atlantic and Pacific is taken by the region of calms. Now as in this region western and south-western winds are more prevalent than others, it was thought that north-west monsoon did not require a particular explanation. But the supposition itself was ill-founded. For in the Atlantic and Pacific the region of calms lies north of the equator, and the west monsoon exercises its influence only on the sea south of the line. The difference between them is also proved by the latest accounts, according to which the region of calms and the west monsoon exist separately in the Pacific. Until within a few years this monsoon appeared only to play a subordinate part among the monsoons. But it now appears to constitute the leading feature, as it has been discovered that it extends into the Pacific, to the very centre of that ocean, or to more than half-way between New Guinea and America. For, as we observed in speaking of the trade-winds, its effects are experienced as far east as the Marquesas Islands. From these islands (140° W. long.) the western monsoon is met with westward to the northern extremity of Madagascar (315° W. long.), so that it blows over one hundred and seventy-five degrees of longitude, or nearly over one-half of the globe. Every one who considers the nature of this monsoon, will be aware that the principles on which the explanation of the trade-winds rests are quite insufficient to convey an idea of the manner in which the west monsoon originates. That the almost innumerable islands and coral reefs with which the Pacific is beset between the equator and the southern tropic materially contribute to the formation of this monsoon, can hardly be called in question; but in what manner their influence is exercised remains a secret. Here, too, it is evident that there must exist in the atmosphere of our globe a process of nature with the laws of which we are not yet acquainted.

The force with which the monsoons blow is much greater than that of the trade-winds. When in force they blow a moderate gale, and even a fresh gale. In such cases a vessel can hardly carry all its sails, and is obliged to proceed with the upper sails reefed, and sometimes double-reefed. The force of these winds, added to the circumstance that the currents always flow with the wind and run with great force, renders it an extremely tedious and laborious task to work up against them. Frequently it is quite impossible to stem their violence in any way. Nothing can be gained by tacking and hugging the wind close. Many vessels, which have made efforts to force their way against it, have been compelled to give in, and to enter the nearest harbour to wait until a change of the monsoon takes place. Other vessels have been obliged to change their course, and to reach their place of destination by following a different track, wide of the straight route, and thus avoiding the monsoon. When vessels sailing from Europe to China are by some accident prevented from reaching the region of the monsoons in the favourable season, they find themselves reduced to the alternative either to remain in harbour for four or five months, or to leave the direct track for another along which the wind is more favourable to their progress. Thus a vessel bound to Canton, and arriving in Sunda Strait in the beginning of December, cannot accomplish its voyage by running north and north-east through the Chinese Sea, as in that and the following month the north-east monsoon is too strong, and opposes the progress of the vessel with too great violence. She must, therefore, take another route, where the obstacles are less powerful. The Straits of Macassar, between Borneo and Celebes, offer such a route, as it lies from south to north. Having passed through it, the vessel finds a northern wind in the Celebes Sea, and must pass eastward into the Pacific, leaving the island of Sanguir on the right. But the Straits of Macassar are only practicable for such vessels to the end of December or the beginning of January. Later in the season northern winds prevail, and are attended with strong currents and a very rough sea. Then the vessel must sail farther to the east, pass round the southern extremities of Celebes, and hence direct its course through the Molucca Sea towards the north-western extremity of New Guinea, near which it passes through Pitt's Strait or Dampier's Strait into the Pacific. This route is very dangerous on account of the rocky islets which are dispersed in great number over this part of the Indian Ocean, and it is only open to the middle or, at the utmost, to the end of February. But as about the same time the strong northern winds and southern currents in Macassar Straits abate, the vessel may then take the route through that strait. All the vessels which are compelled to follow these tracks must enter the Pacific, and proceed in it as far as 135° E. long., whence they direct their course to the Chinese Sea, and enter it by the Straits of Formosa.

But though the monsoons, to vessels which miss the right season, render the voyages long, tedious, and laborious, they greatly promote those of ships that arrive in these seas at the right period, and more than other winds. It is chiefly by the assistance of the north-east and north-west monsoons that the voyages of mercantile vessels bound from Canton to England are accomplished in the comparatively short period of 120 days, or four months, as the space they have to traverse does not fall short of 14,000 miles, so that the progress of the vessel is nearly 120 miles per day. The advantages which vessels sailing from Europe to Calcutta, Singapore, and Canton, derive from the south-west monsoon, are nearly equal, though their voyages are considerably longer, which is to be ascribed to causes not connected with the monsoons.

Great as the advantages are which the trade and navigation of the Europeans derive from the monsoons, they are but very small when put into comparison with those which are imparted by them to the inhabitants of those countries which are placed within the reach of these winds. Their intercourse by sea is very easy and certain at the same time. With one monsoon their vessels leave their country, and with the other return to their homes. Chinese vessels from Canton and other places in the neighbourhood leave their ports in January, when the north-east monsoon is in force, and after a voyage of twelve or fifteen days they arrive at Singapore, where in a couple of months they sell their cargoes; and after having settled their affairs they return home, towards the end of April, with the south-west monsoon, with what they have bought at Singapore for the Chinese market. The return voyage does not take more than twelve or fifteen days, for on both voyages they have continually a fair wind. The construction of their vessels is adapted to the strength of the monsoon, and they do not carry more sail than the wind permits. To these circumstances probably it is to be attributed that among the vessels of the natives of those countries the shipwrecks are not more numerous than in other parts of the ocean, though the Chinese Sea is much dreaded by European seamen on account of its numerous rocky islets.

We find that by nature the whole ocean is divided into three regions, which are under the influence of the trade-winds, of the monsoons, or of variable winds. It is here perhaps not out of place to take a rapid view of the advantages navigation derives from the prevailing winds of each of these regions, by inquiring in which of them navigation has been earliest practised. We shall first mention the fact, that even at present those nations which carry on navigation on a large scale, are found to inhabit those countries only which surround the region of the variable winds in the Northern Atlantic, and those which lie within the reach of the monsoons. All other nations have either no seafaring vessels at all, or only such a small number as not to be taken into account in a general view of the subject.

When we consider the peculiar nature of the trade-winds, we must be directly aware that no portions of the ocean are less favourable to the first attempts of navigation than those which are governed by these winds. With their aid, adventurers may easily get far from their countries, but they preclude the possibility of their returning. Under such circumstances, it can never have entered the head of a man to make the attempt of navigating the sea at large. It is therefore probable that the region of the trade-winds was never navigated until it was entered by seamen who had acquired skill in turning to account every kind of wind, by a long practice in the region of the variable winds. Such seamen alone could muster courage to enter on so arduous an enterprise, from the difficulties of which they could only disengage themselves by their superior skill in managing a ship. We may here remind the reader, as a fact in support of this opinion, that the Portuguese, in their ever-memorable first voyage round the Cape of Good Hope, never met with a vessel larger than a moderate fishing-boat on the western shores of Africa, nor on the eastern until they arrived at the town of Mozambique, which is built, as it were, at the very entrance of the region of the monsoons; for the north-east monsoon extends far southward into the strait which separates the island of Madagascar from the African continent. In the harbour of Mozambique, however, the Portuguese found seafaring vessels, and pilots who conducted their vessels through the region of the monsoons to the shores of Hindustan.

The first attempts at navigating the region of the variable winds must certainly have been beset with great difficulties, and their progress in navigation must have been very slow. We shall not dwell on the great skill it required to meet promptly all the changes of the wind, both in direction and strength, which skill could only be acquired in a period of many generations. A much longer period must have passed before long voyages were undertaken. It certainly soon became evident that it was very possible to accomplish long voyages, but still there remained a doubt, if not respecting their issue, certainly respecting their duration. This uncertainty must for a long time have kept the minds of the adventurous seamen in suspense, and limited their voyages to comparatively short distances. How many centuries may have passed before, aided by circumstances and successful attempts, their skill and courage increased to such a pitch as to enable them to extend their voyages farther and farther, until at last they succeeded in subjecting the whole region of the variable winds to their power, and then found themselves sufficiently prepared to contend with the trade-winds!

The seamen of the region of the monsoon had not to pass through this long course of preparatory training.

When they had observed for a few years the regularity with which the changes of the seasons and the winds followed one another, they soon comprehended that there was no danger of being cast away from their homes, even in long voyages. The first adventurers abandoned themselves to the winds and currents, without caring how far from their homes they were carried by them, being convinced that, after a few weeks or months, another wind would spring up which would safely convey them back to the places whence they had departed. There can therefore be hardly any doubt that navigation, on a very large scale, was practised in these seas at a very remote period, and it is even not improbable that from the Arabian Sea it was introduced into the Persian Gulf, where, according to the statement of Herodotus, the Phœnicians originally resided; and that, at the time of their migration, the art of navigation was introduced into the Mediterranean, whence it spread over the regions of the variable winds of the Atlantic, where it has attained the highest degree of perfection. The opinion that navigation is of very ancient date in the region of the monsoons is supported by two facts: by the high degree of civilization the inhabitants of some of the countries which are adjacent to the seas swayed by these winds have attained; and by the great extent to which navigation has always been practised, and is still, in these seas. The inhabitants of China and Hindustan are certainly acquainted with all the arts of civilized life to a great degree, and their history shows that they have been in possession of them for a time out of memory. It may be objected that other nations similarly situated, as the Malays, have stopped at a comparatively low stage of civilization. This must be ascribed to other circumstances. There are no seas which abound more in fish than the regions of the monsoons, especially that portion of it which lies south of the equator; and it affords to the Malays as plentiful a subsistence as agriculture would do, and that with less than half the labour which the latter would require. Besides, they are so situated that they can with the greatest ease communicate with those countries which, by their greater degree of civilization, can furnish them with all those necessaries of life they are in need of, and which they cannot procure in their own country. They go to these countries in their own vessels; for if we except the civilized countries of China and Hindustan, we find that the larger portion of the population of the countries subject to the monsoons is composed of fishermen and seamen, and their vessels are met with everywhere as far as the monsoons extend. This is the reason why the number of European vessels engaged in the trade of these parts is so limited. These vessels are only employed in supplying a few places, where depôts of European merchandise have been established, with those goods which are in demand among the inhabitants of the islands, but they do not convey them to the places where they are consumed. Native vessels, in considerable number, arrive annually at such places as Singapore, Batavia, and Surabaya, to dispose there of the produce of their countries, and to buy foreign goods, which they afterwards disperse over all the islands of the Indian Archipelago and the neighbouring countries. But though the monsoons greatly facilitate navigation within the limits of the region in which they prevail, they render their seamen unfit for extending navigation beyond the boundaries of the region. They have no opportunity of acquiring the skill and courage which are required to contend with the dangers and difficulties to be encountered in the regions of the variable winds and of the trade-winds. We must therefore consider the introduction of navigation into the Mediterranean by the Phœnicians as an event which has promoted, more than any other recorded in history, the civilization of the whole human race, and changed the face of the globe.

We have mentioned the abundance of fish found in those seas which are swept by the monsoons. The quantity and variety of fish, shell-fish, mollusca, and crustacea, which are met with in these seas are almost incredible. We know this fact with certainty respecting the seas which extend from Sumatra eastward to New Guinea, but it would appear that fish is as abundant to the east of the last-mentioned island as to the west of it. We must at least adopt such an opinion when we find that the inhabitants of the islands lying between New Guinea and the Viji group show their ingenuity, and the progress they have made in the arts of civilized life, in nothing so distinctly as in the construction and outfit of their boats. To what an extent fishery is carried on in these seas may be inferred from the fact that as many as four hundred fishing-boats have been counted at once from the deck of a European vessel in the sea which surrounds the southern shores of China. We are very imperfectly acquainted with the kinds of fish which frequent these seas; but we know that, besides the enormous quantity of fish which is consumed by the inhabitants, who prefer them to all other food, there are several kinds which are cured for foreign markets. Among them the sea-slug, or bêche-de-mer, is by far the most important. It is conveyed in a dried state to China, where it is considered a dainty, and fetches a very high price. If we can place any reliance on the information which occurs only occasionally in books of travels, we must be persuaded that the number of fishermen who are engaged in this branch of fishery, between the shores of China and those of Australia, is greater than that of those who derive their subsistence from the cod-fishery on the banks of Newfoundland and along the coasts of Norway. The great abundance of these sea-slugs, and the ready market which is found for them, has given rise to a tribe of itinerant fishermen called the Bajoos, who have their station along the eastern and north-western coasts of Borneo. They have no other abode but their boats, in which they have their families, and in which they pass their whole lives. In these boats, which are of about five tons burden, they shift to leeward, from island to island, with the variation of the monsoons. Their occupation is limited to the catching of sea-slugs, and to curing them for the market.

It is a well known fact that in all countries the climate is modified to a smaller or greater degree by the prevailing winds, but the monsoons alone appear to possess the power of infringing that order of nature, which in other countries similarly situated between the tropics is considered as immutable. In all intertropical countries, as it is known, the year is divided between the dry and the rainy seasons. The rains commonly begin when the sun enters the hemisphere in which the country is situated, at some places somewhat sooner and at others later, and they last until the sun has again returned to the equator and is passing into the opposite hemisphere. Some countries have two rainy seasons, each of them falling in the time when the sun approaches the zenith of the place, either receding from the equator or approaching it. These two rainy seasons must, however, be considered only as portions of one rainy season, which is divided by an interval of a few weeks of fair weather into two parts. When the sun is in the other hemisphere most of these countries have not a drop of rain for six months. It is evident that in all these countries the seasons are dependent on the position of the sun, and that the heat produced by the sun in the atmosphere is the sole cause of these changes. This order of the seasons is considered in these countries as an immutable law of nature. In countries situated in seas where the monsoons predominate there are also two seasons, the dry and the wet, but they do not depend on the position of the sun; they are regulated by the monsoons alone. Thus we find that when the sun is in the southern hemisphere, the coast of Coromandel, though situated in the northern hemisphere, is drenched with rain by the north-east monsoon, and the rains are most abundant when the sun's perpendicular rays fall on the countries situated in the vicinity of the southern tropic. Between the rains brought on by the monsoons and those which are to be considered as dependent on the march of the sun, there is another remarkable difference. The rains of the last description extend over the whole country uniformly, and when there is a difference in their quantity, it commonly may be accounted for by local circumstances. But the rains which attend the monsoons do not extend uniformly over the whole country, but only over those parts which lie near the coasts on which they blow. They certainly, in many cases, advance to a considerable distance inland, but at the same time they diminish in quantity in proportion as they recede from the shore. All these circumstances impart to the climate of these countries a quite peculiar cast. It happens frequently that one part of the country is drenched with rain, whilst not a drop falls in another part, that one tract suffers by the superabundance of moisture, whilst another is burned up by an extreme dryness of the atmosphere and a powerful sun. Thus the western shores of the peninsula of Hindustan have very heavy and almost continual rains during the south-west monsoon, which wind brings only a few very slight showers to the eastern shores of that country. On the contrary, during the north-east monsoon the rains are abundant on the eastern shores, whilst not a drop of rain moistens the western coast. Another point which deserves to be noticed is the difference in the quantity of rain, which is great in countries exposed to the immediate effects of the monsoon and situated at no great distance from each other.

We have before noticed the different quantities of rain which fell during the south-west monsoon at Tellicherry, Bombay, Calcutta, Benares, and Aracan. It is not easy to assign a cause for this difference. It would however seem, that two circumstances are most powerful in bringing about this effect, the position of the coast with respect to the direction of the wind, and the existence or absence of high and steep mountains in the vicinity of the shores. When the monsoon blows on a coast-line under a right angle, and is arrested in its progress by high and precipitous mountain-masses, all the moisture with which it is loaded, or which it generates on coming into contact with the air of the land, is discharged on a tract of comparatively small extent, and in such places the quantity of rain is immense, as is the case with Chittagong and Aracan. The coast of Malabar receives the blasts of the winds under an angle somewhat less than a right one, and though the Gaut Mountains are not far distant from the shores, the quantity of rain is considerably less, though still very abundant when compared with other parts of the country. The delta of the Ganges, and the coast opposite the town of Bombay, present to the sea a front line which forms a much lesser angle with the direction of the wind than the coast of Malabar. Accordingly we find that the quantity of rain which falls on the delta of the Ganges amounts to hardly one-third of that which descends on the low country of Aracan, and at Bombay only half the quantity of rain is experienced which drenches Malabar, though opposite Bombay the mountain-masses advance as near to the sea as at Tellicherry.

The effects of the monsoons in changing the seasons are nowhere better exemplified than in the island of Sumatra. This island is traversed by the equator nearly in its middle. The northern portion therefore lies within the region of the north-east and south-west monsoons, whilst the southern half is exposed to the effects of the north-west and south-east monsoons. This produces different seasons, not, as in other parts of India, on coasts which have a different position as regards the points of the compass, but even on coasts which lie in the same direction, and are contiguous to each other. The south-western coast of Sumatra lies, when the sun is in the southern hemisphere, under the influence of the north-east monsoon north of the equator, but the southern half is within the reach of the north-west monsoon. The north-east monsoon passes over the low isthmus of Krau, which connects the Malay peninsula with the continent of Asia; but in arriving at Point Acheen, the most northern point of Sumatra, its direction is influenced by the position of the island and its mountain ranges, and is inflected towards the south, so that along the south-western coast it blows from the north-west. During its prevalence that portion of Sumatra has its dry and fair season. But the north-west monsoon, which at this season prevails along the southern half of the south-western coast, empties its abundant rains on its shores. Thus, apparently, the same wind brings to the northern districts fair weather, and to the southern rain, forming a very striking irregularity. During the opposite season, when the sun has a northern declination, the south-western monsoon prevails along the northern coasts, and brings rain, whilst the southern parts enjoy fine weather, brought on by the south-eastern monsoon. On the north-eastern shores of Sumatra the seasons are not well marked. When the sun is in the southern hemisphere the north-east monsoon, as it appears, prevails along the whole extent of this coast, but within the Straits of Malacca it is very irregular, being frequently interrupted by other winds or calms, so that it entirely loses its character; and the same may be said of the south-west monsoon, which predominates in the opposite season. The force of the monsoons, it appears, is broken by the mountain ranges which enclose the strait on both sides. To these circumstances also is probably to be ascribed the fact of rain occurring all the year round on both sides of the Strait of Malacca; it is, however, not abundant, though frequent. The most heavy showers fall between the end of September and the end of November; that is, in those months when the south-west monsoon changes into a north-east monsoon. But the southern part of the north-eastern coast of Sumatra has regular dry and wet seasons. The rains are brought to it by the north-east monsoon, which in these parts commonly advances to a distance of two or three degrees south of the equator. The dry season is brought on by the south-east monsoon.

The Island of Borneo is also traversed by the equator nearly in its middle, and offers another deviation from the common course of the seasons, but of a different description. Though this island is assailed by all four monsoons, its two seasons fall on the same months of the year all over the island, which does not happen in any other country of similar extent within the reach of the monsoons. This apparent irregularity is to be ascribed to the circumstance, that the rainy season on the north-western and north-eastern coast is attended by the north-east monsoon, as in Coromandel and Cochin China. As in the same period of the year the west or north-west monsoon prevails on the southern districts of the island, and drenches them with rain, the whole of the Island of Borneo has its rainy season when the sun is in the southern hemisphere, from October to April, and its fair season in the other half of the year.

The setting-in of the south-west monsoon and of the rainy season is attended with very remarkable phenomena on the coast of Malabar. In the month of February the low country between the sea and the base of the Ghaut Mountains becomes excessively hot, though the sun is then in the southern hemisphere, and far from the equator. After some days the air begins to be charged with vapours and exhalations so dense that it is difficult to distinguish an object at a distance of a few miles: which curious process may then be viewed from the top of the mountains, where the cold is scarcely supportable. The heat increasing during the months of March and April, a prodigious quantity of aerial moisture is collected, which remains day and night in a floating state, sometimes ascending nearly to the top of the mountains, where it is checked by the cold, and then descending is again immediately rarefied, and becomes vapour before it can reach the earth. In this state of buoyant perturbation the atmosphere continues until the setting-in of the monsoon, which is attended by loud claps of thunder and violent gusts of wind. By their intervention the vapours are condensed into rain, but not at once, for during the first two months the rains are by no means excessive. They become so in June, and are attended by the most violent squalls of wind, during the prevalence of which all trade is suspended, and ships disappear entirely from the coast, all insurances being void until the end of September, when the monsoon moderates, and the rain abates. From this account it is evident that the rains brought by the monsoons are not produced by condensation of the moisture which the wind has collected in passing over a large extent of sea, but that its elements are generated on the land itself, and that they rest suspended in the hot air until condensed by the monsoon, and converted into rain. This opinion receives a strong support from the fact that navigators traversing this sea during the south-west monsoon usually enjoy moderate and fine weather, with a cloudless sky overhead and a clear horizon, as long as they remain at a certain distance from the shores of Malabar.

Section X.—Plains and Deserts.

Vast plains possess but few attractions: they excite little interest, and few visit them for pleasure; whilst mountainous districts are frequently crowded by travellers from the remotest countries. What hosts of visitors are continually met with in almost every valley of the Alps, whilst a person may traverse the plains of Hungary, from one extremity to the other, without meeting a person whose residence is not in the next village or town. This preference is owing to the scenery exhibited; to the variety, beauty, and grandeur of the objects presented by mountain regions. The continual alternation of hills and dales, of wooded slopes, naked precipices, craggy peaks, rugged rocks, limpid streams, fertile glens, grassy pastures, cultivated fields, and groves of fruit trees, together with glaciers and snow-capped mountains, are found within small distances of each other, so that all these objects may be seen in the space of a day or little more. The eye and the attention of the spectator are kept in uninterrupted activity. New objects perpetually crowd on his attention, impressing the mind with new ideas. He feels his mind and his body excited to the highest degree. Very different are the impressions experienced by the traveller who traverses a plain. If its surface is not level, but diversified by low hills, it presents from time to time some object to attract attention; and when human industry has been applied with success to the cultivation of the country, he will feel considerable interest, diffusing a certain degree of pleasure over his feelings. In viewing an extensive level plain for the first time, and from a height considerably above it, the first impression is rather grand from its extent, especially when the traveller has been for many days in valleys and between high mountain ranges. When the Plain of Lombardy is first seen from the heights of the Alps, it presents itself to the eye like a boundless garden, and the impression is pleasing. But in travelling over it all interest begins to die away, and the continual sameness of the scenery rapidly becomes tiresome. In the Plain of Lombardy, and similar places, some interest is created by the sight of the monuments of the successful industry of man, the towns, villages, plantations, and well-cultivated fields: but where such objects are wanting, the tiresomeness passes by degrees into listlessness, which, when continued for any length of time, produces complete exhaustion. A visit to a mountain region may be compared to a succession of joyful occurrences; a visit to hilly tracts, to the events of common life; and a journey over an extensive uncultivated plain, to the feelings excited in an active man, used to constant occupation, by a continuance of forced inactivity, or to those of a man accustomed to rambling, and now undergoing the punishment of solitary imprisonment.

Though large level plains are avoided by persons who travel only for pleasure, they yet deserve to be noticed as one of the prominent features of the globe. Importance is attached to them partly from their extent, and partly from their capacity of supporting a numerous population. The last quality, indeed, belongs only to some of them in any eminent degree, whilst others are possessed of so few resources in this respect, that they have justly been named deserts or wildernesses. In the great plain of northern China the population is so closely packed, that it has been thought necessary to introduce some usages, and to enact laws, by which the most common actions of man are regulated, merely for the purpose of preventing persons from coming into too close a contact to one another; whilst in the Sahara a traveller may continue his progress for days or weeks without seeing a human face. The Plain of Lombardy is covered with towns, villages, and plantations, whilst in the Llanos of South

America the isolated dwellings of the herdsmen are many miles distant from each other.

If the importance of plains were limited to their capacity of furnishing subsistence to man, they would be chiefly objects for the attention of those who occupy themselves with statistics; but they exhibit the greatest variety in the intellectual and moral development of the human race. The inhabitants of two widely-distant mountain ranges, situated in different zones, resemble each other far more in character, ideas, occupations, manners, and customs, than those of two large plains similarly situated. Many points of strict resemblance exist between the inhabitants of the Alpine valleys, which are from three thousand to five thousand feet, and those of the Himalaya Mountains, occupying slopes from five thousand to seven thousand feet above the sea-level; and both differ but slightly from the tenants of the Andes, who reside near the equator in mountain recesses from seven thousand to eight thousand feet above the sea. This cannot be a matter of surprise, when it is considered that all these mountaineers inhabit tracts which resemble each other in climate, fertility, productions, and scenery—circumstances which, more than all others, are operative in forming characters, opinions, and usages. At the respective elevations above stated, the climate of these regions cannot differ greatly. Valleys in general present less variety of soil than exists in a flat country. Their soil is formed partly by gravel, which by abrasion has been detached from rocks, and partly by earthy matter, which has been washed down by rains. There may exist a difference in the proportion of these constituent parts, but this difference is not great. As the great mountain ranges consist either of the same or similar kinds of rocks, the fertility of the soil does not differ materially. Some difference may certainly be found in two valleys not far from one another, but not enough to be taken into account in a general view of the subject; and it may be taken as an established fact, that the valleys of mountain ranges do not exhibit any considerable difference in the fertility of their soils. Where the climate and soil of two tracts resemble each other, it is found that the vegetable productions are similar, and that nearly the same degree of industry and care is required to produce them. The same observation applies to domestic animals. The scenery probably exhibits a greater difference than what exists in the climate, soil, and productions, in the three above-mentioned mountain ranges, and must in some degree affect the mental development of their inhabitants, though these differences, few in proportion to those which are found between the inhabitants of plains, may be partly accounted for by variations in the religion, in the race from which the mountaineers have sprung, and still more from the political state of the bordering countries. As, for instance, all mountaineers believe that they are superior in courage and enterprise to their neighbours inhabiting and cultivating the lower country; they are inclined to levy contributions on them, and to keep them in a state of subjection, when their attempts are not checked by a regular and effective government. The Swiss did so during the middle ages in those portions of the Plain of Lombardy which lie close to their mountains, and the Scotch Highlanders of the Grampians levied black mail from the Lowlands. The Abors, inhabiting the Himalaya Mountains north of Asam, and the Singfos, living on the mountains south of the Brahmapootra, levied contributions from the Asamese as long as the government of that country was in a distracted state, and did not abandon their claims until compelled by the British authorities.

How differently are the inhabitants of great plains affected by their position! Two plains can only influence the formation of the character of their inhabitants to an equal extent, and effect a certain similarity of ideas and customs, when they have a similar soil and climate. But their soil exhibits all the different shades which lie between the rich alluvial deposits of the Chinese plains and the bare, smooth sandstones, or the loose sand, of the Sahara. Their variety in this respect is beyond enumeration. Hardly less different is their climate. It is not only affected by their geographical position in latitude, but frequently also by their longitude. Another diversity in the climate is the effect of their elevation above the sea-level. A plain situated in the torrid zone, when raised by the subjacent mountain-masses to an elevation of 5000 or 6000 feet above the sea, is as it were transplanted to the temperate zone, and its productions are so changed that this alone must greatly surprise a person not familiar with the fact. All these varieties of climate and soil impress lasting effects on the character of the inhabitants, and promote or retard their mental development. One of the most striking instances of these effects is exhibited in the different character of the Mongols and Chinese. The Mongols are proud, frank in their manners, independent in their behaviour, courageous, disregarding conventional practices, religious, superstitious, idle, impatient of control, inclined to change, active but incapable of continued labour, and rebellious against established order if contrary to their inclinations. The Chinese are simple, submissive, crouching, cautious, cowardly, tenacious of social ceremonies, strict observers of conventional manners, freethinkers, regardless of religious tenets but adhering to the ceremonies of their creed, laborious, industrious, obedient to laws and government. There are hardly to be found on the whole surface of the globe two nations which differ more from each other than the Chinese and Mongols, yet they belong to the same race, and live in countries which border on each other. But the plains in which the Mongols wander are at an average 3000 feet above the sea-level, and their surface is covered with gravel, sand, and stones; whilst the Chinese cultivate an alluvial plain, more fertile than any other portion of the globe, and but little elevated above the sea. Though subject to the same authority, they are governed by distinct laws, and an administration which is organised on different principles.

It is certainly interesting to trace the connexion between the physical constitution of a country and the mental development of its inhabitants, and such is the purpose of the following essays on the Desert of the Sahara, the Selva of the Amazonas, the Pampas and Llanos of South America.

SECTION XI.—THE SAHARA.

THE Sahara, whose full name is Sahara-bela-ma, "the Desert without Water," sometimes also called the Bahar-bela-ma, "the Ocean without Water," is a region of immense extent, occupying the central parts of Northern Africa. On the west it reaches the very shores of the Atlantic Ocean, between 15° and 30° N. lat., and hence it extends eastward nearly across the whole continent of Africa, being separated from the Red Sea only by the valley of the Nile and the rocky country beyond it. Its length in this direction is not less than 2650 miles. Its width is various. The widest part is between 0° and 10° E. long., where the desert occupies nearly eighteen degrees of latitude, or about 1200 miles. But farther to the east it narrows at one place to ten degrees of latitude, or 700 miles. It is certain that we do not overrate its extent by assigning it an area of 2,500,000 square miles, which is more than two-thirds of the area of Europe.

This immense region enjoys a smaller share of the gifts of nature than any other known portion of the globe. Soil and climate are unfavourable to vegetation, and consequently afford very sparingly the means of sustaining animal life. It is, however, not uniform in this respect. Near 15° E. long. the desert is crossed by a more favoured tract, in which Fezzan is situated; a district of which the soil at several places consists of clay capable of producing a kind of millet, and where groves of date-trees are numerous. Between Fezzan and Lake Tchad several stony ridges occur, at the bases of which wells are found, and in their neighbourhood are some extensive plantations of date-trees, with pasture-grounds for cattle. But between them lie tracts, composed of loose sand, in which the camels sink nearly knee-deep, and quite destitute of vegetation. No water can be obtained in them. In approaching Lake Tchad the sandy soil is interspersed with clumps of grass, and here and there with low bushes, which are soon succeeded by trees, increasing in number and size until the town of Lari is reached, situated at a short distance from Lake Tchad.

By this tract the desert is divided into two unequal portions; the eastern and smaller called the *Lybian Desert;* the western and larger the *Sahee.* On both regions nature has strongly impressed all the characteristics of sterility, but still there is some difference in soil and climate. The Lybian Desert is superior in both respects. Its surface, in most places, is not covered with sand, but is formed of a hard sandstone rock with horizontal strata, on which the traveller may not find a single grain of sand for several days. The rocks are as smooth and level as a bowling green, not exhibiting the least furrow or depression of the surface for hundreds of miles. Nothing is to be seen but the hard pavement under foot, and the cloudless sky overhead. At last the scene changes. The sandstone is succeeded by gravel, frequently interspersed with rounded pebbles. The surface continues to be flat, but is frequently furrowed by ravines and glens, sinking sometimes to thirty feet below the general level, and in these depressions a few bushes are met with. Round these bushes the finer sand, brought by the easterly winds, frequently collects, so as to form small sand-hills. Some portions of these gravelly plains are impregnated with salt, and there are spots which are covered with incrustations of that mineral, so as to appear as though they had a slight covering of ice. At a few places there are short ridges of low limestone hills, especially in the northern parts, one or two of which rise so high as to be called mountains. But these tracts are likewise barren. All these plains and ridges bear the sign of utter sterility, and exhibit hardly any trace of vegetation. However, there occur in the plains occasionally, but at great distances from each other, depressions which sink below the thick stratum of sandstone constituting the general surface, from under which the small quantity of water deposited finds its way to the surface of the depressions in the form of springs, being at some places so copious as to be used for the purpose of irrigating the adjacent lands. The soil, though mostly composed of sand, contains some earthy matter, which renders it in some measure fruitful. On the fields rice and millet are cultivated, and there are groves of date-trees and doum-trees, both bearing edible fruit, which is gathered with care. Other trees, especially acacias, and yews, occur occasionally. The inhabitants keep sheep, goats, and fowls. These depressions are called oases, and some of them are of considerable extent. The largest is about three days' journey from the banks of the Nile, and is called Wadi-el-Kharjeh. It is nearly a hundred miles in length from south to north, with a width varying between one and fifteen miles. Several other oases, but of much smaller extent, occur in the desert at a distance of between three and five days' journey from the banks of the Nile. They are less frequent in the northern districts of the Lybian Desert, but a considerable number of them, according to the account of the natives, occur in the southern parts of it. That portion of the desert which extends west of the Valley of the Nile, participates in the showers of rain which fall in Upper Egypt and Nubia, and the southern are reached by the last and slight offsets of the tropical rains, which drench the countries south of 15° N. lat. The northern parts have no rain at all, as the table-land of Barca preventst he rains prevailing in the Mediterranean from penetrating so far inland.

The oases which lie in the vicinity of Egypt are inhabited by Arabs, who do not differ from the Arabs settled in the Valley of the Nile, and who divide their time between agricultural pursuits and the care of their plantations. The southern part of the desert, as also the tract lying along the road leading from Fezzan to Lake Tchad, is inhabited by the Tibboos, one of the native nations of Africa. In some of their features they resemble the negroes. Their colour is not uniform. In some it is quite black, but many have copper-coloured faces. They are slim and well made, have high cheek-bones, the nose sometimes flat like that of the negro, and sometimes aquiline. Their mouth is in general large, but their teeth fine. Their lips are frequently formed like those of Europeans, their eyes are expressive, and their hair though curled not woolly. The females are especially distinguished by a light and elegant form, and in their walk and erect manner of carrying themselves are very striking. Their feet and ankles are delicately formed, and not loaded with a mass of brass or iron, as is the practice in other parts of northern Africa, but have merely a light anklet of polished silver or copper, sufficient to show their jetty skin to more advantage, and they also wear neat red slippers. The country which the Tibboos inhabit is the best portion of the Lybian Desert; for not only is the number of oases much greater there than anywhere else, but there are large tracts between them, partially clothed with bushes, which afford pasture for camels, and at some places grass springs up abundantly during the rains, affording them the means of keeping herds of cattle.

It is certainly interesting, and the more so because it is unexpected, to find in the centre of Africa a nation which has attained the highest degree of civilization possible under the circumstances in which it is placed. Poor people, it is said, are more economical than rich ones, and this is certainly true when applied to nations. A people inhabiting a sterile country always direct the efforts of their industry to making the most of its slender productive powers, and manage to live as comfortably and contentedly on its produce as possible. Nothing that can be used as food for man, or be applied to feed domestic animals, is overlooked or neglected. Where the soil, though very indifferent, is strong enough to bear and bring to maturity their only grain, the *gussub*, a species of millet, the Tibboos do not spare labour and care to attain the highest degree of cultivation the nature of the country admits. Where their pasture-grounds are covered with grass, though commonly of a coarse kind, they keep horses, cattle, sheep, or goats to the utmost limits of the produce. Those tracts which do not produce grass, but are overgrown with bushes and thorny plants, are used as pasturage for camels. As such grounds are more numerous and by far more extensive than those which can be sown or depastured by horses and cattle, camels constitute the principal riches of the nation. Some tribes have more than five thousand of these animals. On their milk they live for six months in the year, and for the remainder manage to supply their wants by the produce of their gussub fields. Though the soil is naturally unproductive of plants which can be converted into clothing, they have succeeded in rearing cotton at a few places, but the produce is not adequate to the consumption. Hence they are obliged to buy such stuffs from the cafilas or caravans which pass through their territories, paying for them partly with horses and *maherhies* or swift-footed camels. These camels are so swift that they can perform from eight to nine miles an hour, and so strong, that they will continue at this rate for twenty hours together. These fetch a high price. As however the number of horses and maherhies they have to dispose of is not sufficient to procure all the articles they are in want of, they add such other articles as they obtain by chasing those wild animals which are found in their vicinity, the ostriches and gazelles. For the skins and feathers of the ostrich, and the dry meat of the gazelle, they find a ready sale in the encampments of the cafilas which traverse their country.

In a hot country like that inhabited by the Tibboos there can be no more evident proof of the progress of civilization than that which is afforded by the wearing of dresses. As long as men go naked they are savages in their minds and in their manners. As soon as they put on a dress, they invest as it were their minds with a great number of feelings which before that period were quite foreign to them; with the feelings of propriety, of decency, of modesty, of respect for other people, and of cleanliness. They humanize as it were their minds, and thus they rise in the scale of the human race. Capt. Lyon in his travels in Northern Africa has given a description of the costume of the Tibboos, and added a drawing. It must not be expected that they are elegant and conformable to our taste, but they are certainly decent, and may be considered rather as cumbersome when the climate is considered in which these people live.

Savages live entirely in the air or under the shelter of some branches of trees heaped together on the side whence the wind blows; civilized people erect dwellings. The climate must decide on its form and strength. A hut in the country of the Tibboos gives as much shelter as a brick-built house in England. The villages of the Tibboos are very regularly built in a square, with a space left on the north and south faces of the quadrangle for the use of cattle. The huts are entirely of mats, which exclude the sun, yet admit both the light and the air. The interior of these habitations is singularly neat: clean wooden bowls for the preservation of milk, each with a cover of basket-work, are hung against their walls.

It would appear that the Tibboos, such as they are described, must enjoy, if not the plenty, at least the content which is connected with a pastoral life. But unhappily they are always kept in a state of uneasiness by the enemies who surround them, and who frequently make incursions into their country to capture young persons of both sexes, whom they carry away and sell as slaves. It does not appear that the Tibboos are inferior in courage or activity to their enemies, the Arabs and Tuaricks, but these two nations owe their superiority to the use of fire-arms, of which the Tibboos have so great a dread that they cannot acquire courage to touch them. "Five or six of them," says Denham, "will go round and round a tree where an Arab has laid down his gun for a minute, stepping on tiptoe as if afraid of disturbing it, talking to each other in a whisper as if the gun could understand their exclamations." Their own arms, spears and daggers, they manage with remarkable dexterity, skill, and effect. But as, on account of their agricultural pursuits, they live mostly in fixed abodes, and do not, like their neighbours, lead an exclusively nomadic life, they have not attained that hardiness of character and contempt of danger, nor those habits of depredation, which signalize roving tribes.

The *Sahel*, or that part of the great desert which lies west of the road leading from Fezzan to Lari, contains only comparatively narrow districts along its northern border, which skirts the base of Mount Atlas, and along its southern limit, where it is contiguous with the hilly regions included in Sudan or the land of the blacks, in which tracts of soil, adapted to cultivation, alternate with others whose sandy surface is frequently without any trace of vegetation. All the remainder of the country is quite unfit for any kind of agricultural or horticultural pursuits. It is probable that in the vicinity of Mount Atlas some oases occur with groves of date-trees, and in which some kinds of millet are cultivated, but such spots are rather to be considered as appendages of the countries lying farther north than as parts of the Sahel. The soil of this desert is far from being uniform. In many tracts of great extent, a hundred miles in length and width, a fine loose sand covers the surface, on which low ridges are heaped up resembling the waves of an agitated sea. This sand, however, insensibly passes into a coarse gravel, which affords a firm footing, but commonly is as destitute of vegetation as the sand. At some places this uniformity is broken by the banks of loose stones or rocks, and at a few places hills of moderate elevation afford some variety to the view. Some of them consist of sand, and are subject to be changed in size and form by the wind, and others are composed of compact sandstone or other rocks. As this soil prevails generally over the desert and is completely destitute of vegetation of any kind, except here and there a few hardy shrubs, not affording food to any animal but the camel, it impresses on this region the stamp of utter sterility, and presents the image of complete desolation. But there are also several tracts whose gravelly soil preserves as much moisture the whole year round as is required for the growth of bushes of various kinds, and after the rains a kind of grass springs up in the spaces between these bushes. There the inhabitants of the desert find pasture for their herds of camels, horses, cattle, sheep, and goats. Though some of these tracts are of considerable extent, their scanty vegetation can only support a moderate number of animals, and consequently are not fitted to support a large population, so as to form a numerous community. The inhabitants are therefore divided into a number of small tribes, which frequently, from the want of a sufficient supply of the first necessaries of life, find themselves compelled to take them by force from their neighbours, and thus contract those predatory habits which are more prevalent among them than in any other nation on the globe.

Though even the best soil of the Sahel is but of an indifferent description, many of the tracts where it occurs would be fit for the cultivation of some of those grains which grow in lighter soils, as for instance millet, if nature had added to this gift a common share of rain and dew, or favoured it with an abundant fall of snow. There are numerous tracts, even in Europe, which would be as little fit for producing grain or potatoes, if nature had not provided for their fertilization by an abundance of atmospheric moisture. Snow of course never occurs in so hot a country as the Sahel, and the rains, which are so excessive in almost all those regions which lie between the tropics, are here scanty and precarious. It appears that when nature has poured her bounty over Senegambia and Sudan, which are south of the Sahel, and has little more left to bestow, she sends a few smart showers of rain to the plains parched by the long prevalence of the perpendicular rays of the sun. These happen between August and October, when the sun is leaving the northern hemisphere. It is at this period of the year, and in the months which follow, that the inhabitants venture to pass from one inhabited spot to another. The wells are then full, if the rains have not fallen short of the usual quantity. Though their number is small, and they occur only at great distances from each other, commonly ten or twelve days' journeys, they afford the means of filling the water-skins with which such travellers are provided. If the rains have been scanty or the weather unusually sultry, the wells are found dried up, and the travellers perish. A few months after the rains, the hot wind which sweeps over these plains has dried up most of the wells and every kind of moisture. This wind follows the diurnal course of the sun, blowing almost without interruption from the east, in the daytime, frequently with the violence of a gale, which, however, is generally followed by a dead calm after sunset. The strong wind moderates the heat of the burning sun, and hence the nights are usually more insupportable than the noonday heat. The violent gales frequently raise the loose sand in such quantities that a layer of nearly equal portions of sand and air, and rising about twenty feet above the surface of the ground, divides the purer atmosphere from the solid earth. This sand when agitated by whirlwinds sometimes buries cafilas, and frequently puts them into the greatest confusion. "One of the largest of these pillars of sand," says a modern traveller (Caillié), "crossed our camp, overset all the seats, and whirling us about like straws, threw one of us on the other in the utmost confusion. We knew not where we were, and could not distinguish anything at the distance of a foot. The sand wrapped us in darkness like a fog, and the sky and the earth seemed confounded and blended in one. Whilst this frightful tempest lasted we remained stretched on the ground motionless, dying of thirst, burned by the heat of the sand, and buffeted by the wind. We suffered nothing, however, from the sun, whose disk, almost concealed by the clouds of sand, appeared dim and deprived of its rays." What a degree of heat travellers experience in this desert may be imagined ; it cannot be described.

There are but a few species of wild animals in these wildernesses ; lions and panthers are met with occasionally; they prey on the gazelles and antelopes, which are found in the tracts overgrown with bushes: the first of these animals is rather frequent. Ostriches are very numerous, and they are hunted by the natives in the months preceding the rains for their feathers. No other birds are seen, except vultures and ravens. Along the boundaries only are trees found, chiefly acacias and mimosas. Towards the boundary of Senegambia are extensive woods of the first-mentioned trees, from which by far the greatest part of the gum is obtained which in Europe is consumed under the name of gum-arabic. In the worst parts of the desert a thorny plant occurs occasionally, which is about eighteen inches high, and remains green all the year round. It is eagerly eaten by the camels, and is nearly the only plant which supplies them with food while thus traversing the desert. Without this animal it would be utterly impossible to cross the Sahel in the direction from south to north; therefore the Arabs call it "the ship of the desert."

It is hardly possible to comprehend what motives can have induced men to traverse a wilderness, in which they are exposed to the most exhausting fatigues and to every kind of privation; to hunger, thirst, want of rest, to the danger of being buried under burning sand; where an imminent death must be expected, and that of the worst kind, if it should happen that the water in the next well they are to arrive at be dried up. The desire of gain alone cannot account for it. It is probable that the first attempts were only partial, and were occasioned by one of the most remarkable productions of the desert—its extensive beds of salt. They occur at several places, and we are acquainted with the position of three of them. The inhabitants of the desert themselves make scarcely any use of it in their domestic economy. The countries, however, which border on the south of the desert have no salt, and consume large quantities of it. It, therefore, fetches a high price. This probably first induced men to go half way into the wilderness to bring it to the market. After they had succeeded, and learned to brave the hardships of these travels, they ventured to advance farther northward, until they reached the cultivated country along the southern base of Mount Atlas. Then a regular commerce was established between the countries south and north of the desert, which is carried on by caravans or cafilas, as they are called in Africa, consisting of from two hundred to five hundred persons, and double or triple that number of camels. The merchants bring from Sudan gold, ivory, and slaves, to which they add the ostrich feather of the desert, and they take in return European manufactures, tobacco, dates, and some other articles. The starting points of the cafilas are Timbuctoo on the south, and Fez, in Marocco, on the north. This route lies through the worst part of the wilderness, which is incapable of affording subsistence to a single family. It appears that this route has been purposely chosen, the merchants being less afraid of the danger which they have to encounter in the desert, than of those to which they would be exposed by traversing a tract inhabited by numerous independent tribes, each of which is eager to enrich itself by plundering the cafilas, or by subjecting them to a heavy tax for the free passage through their territories. There is another route across the desert, which lies farther east, and leads from the town of Kano in Sudan, to that of Gadamis in Tripoli; but we are not acquainted with it, as it has never been travelled by any European.

The habitable portions of the Sahel are possessed by two nations of different origin. To the west of the great route between Timbuctoo and Fez live the Moors, and to the east of it the Tuaricks. The Moors of the Sahel are different from the Moors who inhabit the towns of Marocco. They are Arabs, and resemble in almost every particular the Arabs who are settled in that empire, whose language they also universally use. In person they are generally tall and robust, with fine features and intelligent countenances. Their hair is black and straight, their eyes large, black, and piercing, but lie deep in their sockets; their noses are gently arched, their faces long, their cheeks hollow, their beards full and bushy, and they have invariably good teeth. They are more or less swarthy, according to their proximity to the negro countries, until in some tribes they are found entirely black, but without the woolly hair, wide nostril, and thick lip, which particularly belong to the negroes.

As no portion of the territories of these Moors is fit for cultivation, they have less means of subsistence than the Tibboos, and certainly have not attained an equal degree of civilization, at least as far as regards the manner in which they are lodged. As they live entirely on the produce of their herds, and the fertility of their lands is not sufficient to afford food to their animals for a length of time together, they are frequently compelled to move. Hence they do not live in fixed abodes, but in tents, which they remove from one place to another. These tents are of a stuff woven from goats' hair and the fibrous roots of a plant. Such a manner of life would necessarily have contracted the sphere of their ideas and conceptions, if they had not preserved some of the arts of civilized life which they inherited from their ancestors; for they are not aboriginals of Africa, but have immigrated into this desert, when their countrymen extended their conquests from Arabia to Spain. It appears that at that period they exterminated the original inhabitants entirely, and then kept possession of their country. The arts in which they have preserved a considerable skill, are those of tanning and preparing leather; of manufacturing, with only a hammer and a little anvil, bracelets, ear-rings, and necklaces of gold; and of making knives, daggers, and other arms: they are also expert in weaving. Their dress is the Arabic costume, which would appear decent even to Europeans if the arms were not left uncovered. This is done with the view of being better able to use their weapons, which, besides fire-arms, consist of a spear and a dagger. Their residences form circular encampments, consisting of from twenty to a hundred tents, where they are governed by a shieck or governor of their own body. Each encampment constitutes, as it were, a particular tribe, and the tribes bordering on each other are frequently at enmity, which, however, rarely leads to bloodshed, as they are forbidden by their creed, that of Mahomet, from reducing one another to slavery. But where they live at a distance of only a few hundred miles from agricultural districts inhabited by negroes, they frequently make incursions for the sole purpose of capturing young persons to sell them as slaves. As they fall on their victims unexpectedly, and are besides superior to the negroes in boldness, activity, and skill in arms, these predatory expeditions are commonly successful. They are a daring set of people, and not restrained by any scruple in plundering, ill-treating, and even killing persons who are not of their own faith ; but to such as are, they are hospitable and benevolent.

The boldest of these children of the desert are the Tuaricks, who occupy the middle of the wilderness, where it is widest. The form of their bodies and their language prove that they belong to the aboriginal inhabitants of Northern Africa who are known by the name of Berbers. They are a very fine race of men, tall, straight, and handsome, with an air of independence which is very imposing. The colour of their skin is almost white, the dark brown of their complexion being occasioned only by the heat of the climate ; for those parts of their bodies which are constantly covered are as white as those of many Europeans. Their nose is aquiline, the eyes large, the mouth finely formed, the face long, and the forehead rather elevated.

In the north-eastern corner of their country some tracts occur where a small quantity of corn is grown, and where some plantations of dates are found, which yield a fruit of inferior quality. But the remainder of this extensive region can only be used at most as pasture-ground. The tracts yielding pasture are it appears numerous, but of small extent. This obliges the Tuaricks frequently to traverse large spaces of the sandy desert ; and in these travels they acquire that hardiness of character, that firmness of resolution, that quickness of execution, that versatility of mind, and that boldness of enterprise, by which they render themselves formidable to all their neighbours. They are always in a state of enmity with the inhabitants of Sudan, from Lake Tchad to the town of Timbuctoo, making frequent predatory incursions into their country, and carrying off incalculable numbers of slaves. Their expeditions are executed with incredible speed. They use in them only the swift-footed camels, which they manage with great dexterity, fighting when mounted on them, and firing at marks while at full speed, which is a long trot. They are so completely masters of their weapons, and so courageous, that they are much dreaded even by the Arabs, which enables them to pass unmolested, and in very small bodies, countries full of armed people. Caillié states that two Tuaricks, mounted on one camel, arrived at a cafila, consisting of six hundred camels, and all the merchants vied with each other in offering them whatever they chose to eat, and plenty of water, though six days were to pass before they could arrive at a well. They exact a tribute also from all the caravans traversing their country, but in this they show moderation, as clothing, some powder, or any small article, franks the cafila, and this once paid the merchants are exempt from further demand. The Tuaricks wear a very cumbersome costume, as may be seen in Captain Lyon's Travels. This, however, must not be regarded as a sign of civilization, but as the effect of their frequent travels in the desert, where they are often overtaken by a sand-wind. To this necessity must also be attributed the practice of covering their faces as high as the eyes, so that their whole body, except their hands and a very small part of the face, is wrapped up in cotton or woollen cloth or in leather. As they are Mohammedans, they are obliged to perform three daily purifications, and as water is rare in their country they make use of sand in its stead.

SECTION XII.—THE SELVA, OR FOREST DESERT OF THE AMAZONAS.

THE largest river of the globe, the Amazonas, in South America, drains the most extensive forest-plain we are acquainted with. It extends from the mouth of the river westward to the base of the immense rocky masses of the Andes, and in this direction measures at least 1500 miles. Its extent towards the south, and also partly towards the north, has not been exactly ascertained. But a supposition, resting on probable facts, assigns to it, near the mouth of the river, a width of 350 miles, which increases in proceeding westward, so that at the place where the Amazonas is joined by the Madeira the plain is at least 800 miles wide, and still wider where it reaches the Andes. Its surface probably comprehends an area of 1,200,000 square miles, equal to nearly half the extent of the Sahara, and to six times that of France.

The Amazonas is the only river on the globe which is always abundantly supplied with water by the tropical rains. In all the countries which lie south of the river, and are drained by its numerous affluents, rains are very frequent for six months of the year, and during two or three they pour down like torrents. They are less violent and abundant in the countries north of the river, but even these have a fair share of the tropical rains, which bring to the earth's surface between three and four times the quantity of rain which commonly falls on countries which like ours are situated in the temperate zone. It is easily to be comprehended that an almost incredible volume of water must be collected in the bed of the Amazonas. Where it issues from the mountains of the Andes, in which it originates, its width does not exceed a mile, with a depth varying between seven and eight feet; but in proceeding farther east, and after having been joined by the Yupurá from the north, it widens to between three and four miles, at some places even to six; but a large portion of this wide bed is occupied by the numerous islands which the river has formed by depositing alluvial matter. In these parts it is very deep, perhaps sixty or eighty fathoms, but it has been impossible to sound it on account of the rapidity of its current, for it runs commonly at the rate of from three to four miles per hour. This rapidity is not to be ascribed to the inclination of its bed, as its fall is very gradual, but to the immense volume of water which descends in it. Towards its mouth the Amazonas widens to ten, fifteen, and at last to twenty miles, which is about its breadth where it falls into the Atlantic. In despite of its rapid current this river affords a very easy and quick navigation both to vessels descending and ascending its course. The ascent is partly effected by the means of the tide, which advances to a distance of five hundred miles from its mouth, to the Narrows of Obidos, and partly by the wind, which always blows against the course of the river, and by means of which ships, keeping near the banks of the river, and out of the strong current, may ascend it almost with as much ease and in the same time as vessels can accomplish their voyages downward while descending and keeping in the current.

Though the Amazonas always contains a large supply of water, its volume varies considerably according to the season. The rivers which join it from the south, drain a much larger extent of country than those which fall into it from the north. When therefore the sun has a southern declination the supply of water is twice or thrice as large as when the sun is in the northern hemisphere. During the first half of the year its rising, and during the latter half the falling, takes place. The difference of the lowest and highest level of the river is very considerable, amounting at some places to forty feet, but commonly to from twelve to twenty feet. After it has received the vast supply poured into it by the southern rivers, the water overflows its banks, and an immense tract of country is inundated, and the earthy particles which were held in suspension as long as they were in the bed of the river are then deposited on the inundated tracts. Thus in the lapse of time an alluvial soil of great thickness has been deposited on these lands. This soil extends, with the exception of a few small tracts which are above inundation, to a distance of from six to twenty miles from the banks of the Amazonas. As the soil of these low lands is extremely soft, water very easily removes it, and therefore all the smaller rivers and rivulets passing through them divide into several branches before they join the principal recipient of their waters. At the base of the higher country also, which is above the highest level of the inundations, a depression is found, which almost everywhere skirts these higher grounds, and in which a considerable quantity of water gathers from all sides during the rains. These depressions discharge the surplus of their waters by channels running across the alluvial ground. In this manner, on both sides of the Amazonas, a kind of net-work is formed, of which low wooded islands represent the meshes, and the channels the threads. This net-work is found not only on the banks of the great river itself, but also on those of its numerous large affluents. All these large tracts are annually laid under water. The higher grounds, which are not inundated, are mostly level; but at many places depressions of great extent exist, in which the water of the rivers, when it has attained its greatest height, penetrates, and by inundating the lower ground soon forms extensive lakes, deep enough to preserve the water all the year round. These lakes discharge in the dry season a part of their waters, by narrow channels, into the next rivers, but during the rains the channels again carry the water from the river to the lakes, and raise their level, so that a great part of the adjacent tract is also inundated. When the great number of large rivers draining the plain is taken into account, and the great extent of the low lands along their banks, and to these the large tracts are added which lie within the higher grounds, but are subject to inundation from the numerous and large lakes, it may be considered perhaps as no exaggeration when it is stated that one-sixth of the great plain, or 200,000 square miles, are annually laid under water.

The whole of this low region is covered with an exceedingly thick wood. It is composed of large trees of various sizes and heights, and what is very remarkable, they differ greatly in species; no two trees standing together are of the same kind. On a space of twenty square yards perhaps thirty or forty trees are found, but all of different species. The spaces between them are filled up with grass-trees and bushes of different kinds and sizes, standing close together, and the whole is united into one mass by numerous climbing plants and creepers, which as it were constitute the web of the tissue. Thus a woody fabric is raised, as impenetrable to man as a wall of stone, and more difficult to be removed; near the ground only is found here and there a small and low opening, by which the jaguars and other wild beasts find access to the beds of the rivers. These woods can only be entered where they are traversed by water-courses deep enough to be navigated by canoes, but such attempts are usually very laborious: the branches of the trees overhang the channels from each bank, and as they are also entwined by climbing plants, the progress of the canoe can only be effected by cutting the branches. The larger rivers afford a more open and free access, but at many places similar obstacles occur in them.

As these impenetrable woods, along the banks of both the larger and smaller rivers, surround the higher grounds which are not inundated, it is almost impossible to get access to them; nor does it appear that either natives or Europeans have ever settled on these tracts. In the few elevations which approach nearer to the rivers, and which have been reached, it has almost always been found that they are also covered with wood, but of a character less wild and dismal. The variety and confusion of species are not so great, and the trees are commonly less incumbered with underwood and climbing plants.

At a great distance from the banks of the Amazonas there are savannahs, or woodless, grassy plains, which would afford good pasture-grounds, but have not yet been applied to that purpose, being situated too far from the settlements. It is stated, that in those places where the great plain borders on the more elevated regions, these savannahs are more numerous and of greater extent.

The climate of the plain of the Amazonas is distinguished by the quantity of rain, and by an excessive degree of heat. The greatest fall of rain appears to be near the equator, along the banks of the great river. Its annual amount has not been ascertained, but as, in the town of Maranhão, this quantity is not much less than two hundred inches; it is thought that it cannot be less on the banks of the Amazonas. No part of the year is exempt from rain. It falls in greatest abundance between November and March, both months included, but is still frequent to the end of August. In September and October rain is comparatively rare. These rains occur commonly every day, from two to four o'clock in the afternoon, and are accompanied by frightful thunderstorms. The rain pours down in torrents, and Europeans who have not experienced it are unable to conceive its violence. In receding from the equator, either south or north, the seasons become more regular; and between 10° and 20° of latitude, the year is divided between a dry and wet season. The wet season occurs in the southern hemisphere when the sun has a southern declination, and very heavy rains fall in January and February; in the other months they are not so abundant nor so violent. The quantity of rain which annually descends on this region is certainly less than that which drenches the country near the equator. It is further observed, that the rains are less violent and abundant in those countries which approach the base of the Andes than in the eastern parts of the plain. On the north of the river the countries drained by the affluents of the Amazonas do not reach beyond the limits where the equatorial rains prevail. As the plain extends on both sides of the equator, the heat is excessive all the year round. In the interior the thermometer in the shade rises frequently to 106°, when the sun is near the line, and this heat lasts from two to four o'clock; this is a degree of heat not much inferior to that experienced in the Sahara, but its effects on the human body are very different; for the atmosphere resting on the plain of the Amazonas is as distinguished by its humidity as that of the Sahara by its dryness. The sandy desert is therefore healthy, whilst the forest engenders several kinds of fevers of the most noxious description, and enfeebles the frame so as to render it subject to many other diseases. At the period when such a large part of the plain is under water, and also when the water begins to re-enter the beds of the rivers, the evaporation is, of course, excessive, and the atmosphere resembles a vapour bath. But the heat, which causes this evaporation, brings the advantage, that at least a few months of the year are tolerably healthy, namely, the three or four months which precede the rising of the Amazonas in February. If the heat was not so excessive it would not dry up the numerous temporary lakes which are left in the plain by the inundations, nor the large tracts of low marshy ground which during the rains had been converted into swamps.

Moisture and heat are the most effective agents in promoting vegetation, and where both are combined in acting upon a fertile soil, the growth of every kind of trees and plants exhibits an uncommon luxuriance. No soil is more fruitful than that portion of the plain which is subject to annual inundations: hence we find it clad with impenetrable woods, which cannot be cleared but by uninterrupted efforts of severe labour. When that has been done, it requires continual attention to keep it clear, otherwise it is again soon overgrown by weeds and bushes. Travellers have visited spots where Europeans had formed settlements, which for some reason had been abandoned. In ten years they are found overgrown with tall bushes, and in twenty with lofty trees, so that all traces of the industry of man had been completely obliterated, and nature in its wildest form had again taken possession. Though the labour of clearing such lands is very great, the return is in proportion. A space of an acre or two, planted with bananas or mandioca, yields a produce sufficient to afford subsistence to the largest family: but there are only a few isolated and small tracts, which are besides favourably situated, that have been as yet brought under cultivation. The natives here and there cultivate some small spots, in the most slovenly way, more for the purpose of using their produce for the preparation of inebriating liquors than for sustenance, as they prefer animal food, which is everywhere exceedingly abundant, especially as they are not particular in their tastes. Near the settlements of the whites the cultivated spots are more extensive, but still not on a large scale, and their number is small. The woods, however, produce a great variety of fruits and roots which are edible, and besides yield most other objects required in their domestic economy. They afford also articles for exportation, which are in great request, as vanilla, sarsaparilla, caoutchouc, Brazil-nuts, tamarinds, anotto, clove-cinnamon, besides different kinds of balsams and gums, as copal and copaiva, and several species of woods used as dyes, or for cabinet work. There cannot be the least doubt that the number of these articles will be greatly increased when these forests shall have undergone the examination of scientific botanists, and their produce have been subjected to trial. The vegetable riches of these forests will probably be found more numerous and more abundant than those of any other part of the globe.

Not less rich is the animal creation. Those which at present occupy the first place in the domestic economy of the natives are fish, with which all the rivers, small and large, swarm. It is their great abundance, and the facility with which they are caught, which renders the natives averse to every other kind of labour, and secures them an almost certain subsistence without the least care or attention. They have discovered different kinds of plants by which they are able to stupify or kill the fish in the water, and thus procure, by working a few hours and without any effort, a supply for many families and for many days. The number of the species of fish is great, and some of them attain a large size. Next to fish the river-turtles are of the greatest importance. Though not of a size to be compared with the sea-turtles, they are numerous, and from the eggs they deposit on the sandy islands of the Amazonas, a fat is extracted, which, under the name of manteca, is largely consumed in all the provinces of Brazil, and constitutes a chief article of commerce. In some of the larger establishments of the whites, these animals are kept in enclosures made within the bed of the river where it is not deep, and they supply the place of butcher-meat for the table. The largest inhabitant of the river is the manatee or sea-cow, which is not frequently met with, being eagerly sought after by the natives, and the alligator. But though the river teems with animals, the land is in some respects deficient, at least according to our conceptions. There are no ruminants, the closeness of the woods precluding their existence.* The jaguar, which is here of larger size than in any other part of America, and approaches in ferocity and strength to the tiger of Asia, lives on fish, turtles, and monkeys. It is said that it frequently attacks and vanquishes the alligator. The real population of the woods are the monkeys; they are found in incredible numbers and of many species, some of which are of large size. They are hunted by the natives, who dry and eat their flesh. Birds are exceedingly numerous, and some of them have been partially reduced to a domestic state. Serpents, even venomous ones, are frequent, but not half so dreaded as the mosquitos, and several kinds of gnats, as *piums*, *mariums*, *carapanás*, &c., which torment the inhabitants so as to render their lives miserable.

It is evident that these evils, as well as some others which beset human life in the plain of the Amazonas, would be removed if the forests were cleared and the swampy grounds drained, and thus the whole converted into an abode for man. But here the question obtrudes itself, why has it not yet been done? Why has this large country remained since the creation in this state of wildness and desolation, in which it is at present? When we find that there is no country on the face of the globe which can be compared with this plain in the productiveness of its soil, in the creative powers of its climate, which everywhere imparts to its plants and trees the most uncommon luxuriancy of growth, and which fills every corner with animal life of the most various kind—when we hence conclude that such a country must afford the most abundant, almost inexhaustible, means of subsistence to man, and not only provide for his necessities, but also supply luxuries of every description, so as to satisfy the most fastidious appetites and desires—when all this is taken into account, we should expect that such a country, at a very remote period, would have risen from its state of wildness, would have become the centre of a widely-spreading civilization, and the seat of powerful empires, which would have secured peace and protection to many hundred millions of inhabitants by a regular and well-settled government and humane and wise laws. In what condition is its present population? It consists of a number of savage tribes, all of them composed of a comparatively small number of families, some only of three or four. These tribes speak different languages, and have no intercourse with each other, so that they are not acquainted with the language of their neighbours. When the individuals of one tribe visit another, it is only for the purpose of making prisoners, whom they fatten to be eaten at a national festival. They are without government, without any social ties, without religion. When their character and manners, their occupations, food, abodes, and dress are considered, we are tempted to think that they are half-beasts, and little above the brute creation.

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* It is probable that in those parts where savannahs occur some of the smaller species may be found, but we are not acquainted with this fact.

It may appear harsh to pronounce such a sentence on any, even the smallest fragment, of the human race; but let us consider the condition of one of these tribes, living in the interior of the woods, and, as some travellers would say, not tainted with the vices of civilization. The Miranhas live on the banks of the Yupurá, above the cataracts of Cupatí. They are, indeed, not entirely unacquainted with the cultivation of the ground, but it is limited to very small spots, on which they grow mandioca, banana, and anotto, none of the men taking part in working the field, the labour devolving on the women, who are considered as slaves. The men live in idleness at home, eating, drinking, dancing, and sleeping. Sometimes they go out hunting monkeys, or fishing in the river. When one of them intends to make an attack on a neighbouring tribe, he soon finds a few associates. The men wear a stripe of the inner bark of a tree wound round their loins, and another passes between the legs; the women go quite naked, but they paint their whole body, and this, it seems, they consider as a dress. Both sexes perforate the sides of their noses, and place in these holes short thick sticks, by which the parts are so thrust out that they can put them over their ears. This is considered a beauty. In their food they are far from being delicate; but except some cakes made of cassava-flour, and a few bananas, they do not taste vegetable food. When they have monkey-meat or fish, they live on them; but as that sometimes is not at hand, on account of their want of providence and inclination to idleness, they eat alligators, serpents, toads, frogs, ants, grubs, and caterpillars. Their huts consist of a few pieces of wood stuck into the ground, covered on the sides and at the top with palm-leaves; they are rather spacious, and are commonly inhabited by several families. They have a few cooking utensils made in the rudest manner. The rest of the furniture is limited to hammocks, made by the women from the internal bark of the tiriri-tree, and which are so neatly constructed that they are greatly prized by the European settlers, and are in demand even in Surinam and Demerara, to which places many thousands are annually shipped from Para. Except in the manufacture of these hammocks, and in the little care with which the women cultivate a field or two near their huts, we find that this nation is at the lowest scale of civilization, as low as human beings can be.

This becomes more evident when we consider the state of their minds and their domestic relations. They have no idea of God, but imagine that their fate is dependent on the caprice of a bad demon, whose favour cannot be acquired by any action, good or bad. They live only for the present moment, and do not trouble themselves with futurity; and have not the least conception of the immortality of the soul, of future rewards or punishments. Life is considered as being of little value, and death as quite indifferent. Everything is terminated by death, except hatred and the desire of revenge. No affection exists between the sexes; the man associates himself with a woman, and dismisses her at his pleasure. The connexion between them resembles that of beasts of prey: the man cares not for his family so long as he himself is satisfied, and considers his children as a burden, which he endeavours to shun. The children grow up, spoiled by the mother who treats them as playthings, and neglected by the father; without affection for the one, without respect for the other. As soon as a boy thinks himself able to get his subsistence, he emancipates himself from the authority of his parents. Persons who fall ill are neglected and abandoned, because their nursing would subject their attendants to inconvenience which they will not undergo. Every one is his own master, and does as he pleases, and as long as he does not offend anybody he has nothing to fear. These people have no chiefs, and do not obey any orders, except in war, when they subject themselves to the command of him who has projected the enterprise, or has acquired a name by his valour. Since they have begun to have intercourse with the Europeans settled on the banks of the Amazonas, those who have the means of promoting this intercourse have assumed a kind of authority. The only foreign article which is in demand is spirits, for which they give in return the hammocks made by their women, and the prisoners who have fallen into their hands in their military expeditions.

In these expeditions they show that there is not a germ of human feeling in their mind, and display the ferocity of beasts. They do not act as open enemies, nor have they the ambition of vanquishing their adversary, or of obtaining a victory. They imitate the habits of the jaguar. When after a march of many days they approach a settlement belonging to a tribe at enmity with them, they conceal themselves in the woods and bushes, and, when satisfied that nobody is aware of their being near, fall suddenly on the unsuspecting inhabitants, kill all who make the least resistance, take the others prisoners, and oblige them to carry to their own homes the provisions, arms, and utensils which they find in the place. When they have returned to their own settlement they abandon themselves to every excess in eating and drinking, and accompany their feast with frantic dances and undescribable noise. At present they have an opportunity of disposing of their prisoners as slaves to the Europeans settled on the banks of the Amazonas, but it is probable that formerly they ate them all: they still eat some of them. When Martius, a German naturalist who visited this part of the plain of the Amazonas, and to whom we owe this account of the Miranhas, questioned their chief respecting their eating human flesh, he did not deny the fact, but defended the practice by saying, "You whites do not eat alligators and monkeys, though their flesh is well tasted; if you had not an abundance of turtles and hogs you certainly would not be so particular, for hunger is urgent. Everything is habit. When I have killed an enemy I think it much better to eat him directly than to abandon his flesh to putrefaction. Large animals are rare, because they do not lay eggs like the turtles. There is no misfortune in being eaten. Death alone is a hard thing. When I am killed it is no matter to me if my enemies eat me or not. I do not know any kind of animal that has a better taste than our enemies; but the flesh of the whites is tough and sour. I should, however, show very little prudence in eating my prisoners now I have an opportunity of bartering them for spirits. Spirits have a much better taste than blood. But when I take for prisoner one of the Umáua (a tribe with which the Miranhas have a perpetual feud) I kill him directly and eat him, because I am certain that he will starve to death rather than be sold as a slave to the whites." The other native tribes, who are no longer men-eaters, are in great dread of those tribes who have preserved this practice, and narrate with horror that a chief living on the banks of the Rio Negro more than a hundred years ago ate his own wives.

Those tribes which have for some length of time had an intercourse with whites have abandoned the practice of eating human flesh, but it is said that they have contracted a timidity, and evince more cunning, deceit, and lowness of mind, than their neighbours. They have not improved either in other respects. All of them still exhibit a monotonous poverty of intellect and mental torpor, and neither internal emotions nor the impression of external objects are able to rouse their minds from this lethargy. Neither their food nor their dress and habitations have been changed, though they have for two centuries had those of the white settlers under their eyes. They adhere to their ancient usages and practices with an obstinacy which certainly deserves the name of mental torpor. If even they were more accessible to innovation, their ideas of property would much oppose their improvement. Each tribe has its peculiar hunting-grounds, which are marked by well known boundaries; and wherever settled for a time, each tribe or family has its own plantation, which is cultivated by the women for the use of the community. Huts and utensils are considered as private property, though with regard to them certain ideas of common possession prevail. The same hut is often occupied by more than one family, and many utensils are the joint property of all the occupants. Scarcely anything is considered as strictly the property of an individual, except his arms, dress, pipe, and hammock. It is evident that under such circumstances no one could think of accumulating property or of anything beyond the supply of the present wants. Thus the strongest of all stimuli to industry and economy, next to hunger, is wanting among them, and consequently all improvement resulting from that source becomes impossible.

Experience shows that the tribes of the plain of the Amazonas have learnt nothing by mixing with the whites, neither can they improve by an intercourse with their neighbours; for besides that the usages and practices prevailing among these tribes greatly resemble one another, intercourse is precluded by their never-ceasing enmities, and still more by the different languages spoken. "Out of twenty Indians," says Martius, "whom we employed as rowers in the boat in which we navigated the streams of the interior, there were often not more than three or four who understood any common language, and we had before our eyes the melancholy spectacle of persons occupied in the same labour, but entirely isolated with respect to everything which contributes to the supply of the first wants of life. In gloomy silence did these Indians ply the oar together, but no common voice nor interest cheered them as they sat beside each other in a journey of several hundred miles, which their various fortunes had called them to perform together."

That nations which are in a state of such abjectness, and do not evince the least inclination to improve their condition, cannot under any circumstances be expected to render the plain of the Amazonas fit for the abode of civilized man is self-evident. The arts and comforts of civilized life must be planted by foreign hands. Three centuries have now elapsed since the Amazonas was first navigated by an European. In the last two centuries the Portuguese have frequently ascended and descended the river, and during that period settlements have been made at many places by that nation. But still we find that the number of these settlements is few, and that, with the exception of three or four, which are most favourably situated for commerce, their population is very scanty, commonly consisting of a few families in which the number of negroes and other slaves is much greater than that of the whites. Many settlements, formed at places which promised great advantages, have been abandoned, and the wilderness has again extended over tracts which were once cultivated by careful hands. Every part of the Brazilian empire has greatly increased in population, industry, and the arts of civilized life, during the last forty years, but the plain of the Amazonas has remained stationary. Officers who are sent there by the government consider it as a place of exile, and count the weeks and months by the lapse of which they will acquire a right of being recalled and sent to other parts. Persons who by the laws have been condemned to transportation are sent to one of the settlements on the Amazonas. The prospect of accumulating in a short time a large fortune, has also induced many industrious persons to settle, but they look anxiously forward to the day on which, after having attained their object, they will be enabled to leave the country. They do not think of acquiring extensive landed property, or of settling their families permanently. It is not the want of society or of comforts which drives them away; it is the melancholy and irresistible feeling, which imperceptibly creeps into the mind, that they are placed in a desert which cannot be rendered a comfortable home by human industry.

The industry of man has in all other countries succeeded in subjecting the productive power of nature to his sway, and to direct its operation to his ends. In the Sahara it has taken possession of all the resources of the country till it has arrived at the very limits which nature herself has fixed. No farther improvement can there take place. In some countries situated within the polar circle, a course of improvement has been adopted and is pursued with success. Its progress is slow, but certain. The ungrateful soil of the Falkland Islands has fallen under the fertilizing hand of man, and will doubtless be converted into fruitful fields in the progress of time. But there is little hope that such will ever be the case with the plain of the Amazonas. The productive powers of this country, it appears, are too great and too active to be subdued. If its soil was but half as fertile, its air half as moist, and its vegetation half as vigorous as it is, man would easily master nature and compel it to administer to his wants, or to supply him with riches. But he finds here all the efforts of his industry are in vain; he is overwhelmed by the bounties of nature. His mind sinks into despair when he contemplates the immense work before him, whilst his body feels the exhaustion produced by that climate which imparts to the soil its never-ceasing power of reproduction. He finds himself reluctantly compelled to abandon his plans, and to leave to nature that portion of the globe which she seems to have reserved for her exclusive property, and for her unfettered operations. The plain of the Amazonas, is, perhaps, destined to remain for ever a wilderness.

SECTION XIII.—THE PAMPAS.

THE forests of the plain of the Amazonas extend along the base of the Andes as far south as 12° S. lat., where the mountains of Brazil advance so far westward as to leave between them and the Andes what may be called an immense valley, for it is at an average 200 miles across. This valley runs in its northern part, and as far as 18° S. lat., from north-west to south-east, but its southern part extends due north and south. It terminates near 22° S. lat., so that its whole length is not less than 700 miles. In this valley the country changes its aspect by degrees. Its surface is not covered with interminable forests, but presents in the northern districts an alternation of woods and swampy tracts, which are partly overgrown with bushes and partly clad with grass. In proceeding southward the woods continue to be frequent, but less extensive, and the swampy grounds gradually give way to a drier country. These swamps owe their origin to the tropical rains. Where these terminate (about 20° S. lat.) they are succeeded by a region whose surface is dry all the year round, and which is covered in general by a coarse grass, and in some parts by numerous bushes.

The valley just noticed leads from the forest-desert of the Amazonas to the *Pampas*, treeless plains, which from 22° S. lat. extend to the most southern limits of the American continent, and terminate on the Straits of Magelhaens, near 52° S. lat., so that they occupy from north to south a length of 2000 miles. Its width is various. Between 22° and 26° S. lat. it does not exceed 280 miles; but between 26° and 38° it is full 450 miles, between the river Parará on the east and the Andes on the west. Farther south it contracts to 360 and to 240 miles, which is its average width between 42° and 52° S. lat. According to a rough estimate its area is about 750,000 square miles, or nearly four times the extent of France.

This plain presents in its different parts a much greater diversity in surface, climate, and productive powers than the forest-desert of the Amazonas, or the Sahara. The most southern portion, or that which lies south of 40° S. lat., is called the *Pampas of Patagonia*, being inhabited by several tribes which are comprehended under the generic name of Patagonians. We have as yet obtained very little information respecting these pampas. It appears that from the shores of the Atlantic the country rises gradually in proceeding westward until it joins the base of the Andes. At some parts the slope has the form of an inclined plane, whose surface is somewhat hilly, at others the rise is effected by a considerable number of terraces, which grow higher and higher in approaching the mountain-range on the west. In the southern part a great portion of the surface of the plain appears to be overlaid by a thick layer of lava, which doubtless is derived from the numerous volcanoes which existed and still exist in the Andes. These parts are very sterile, but north of 46° S. lat. a large part of the country is clad with grass which affords pasture-grounds for the numerous herds of the Patagonians. But even here there are few trees, and water is scarce, as rain seldom falls. The heats of summer are very great; but in winter, though the days are not cold, the frosts at night are severe, and at all times of the year, in the daytime, strong winds sweep over the plain.

The Patagonians have been considered as the tallest race of men since they were first visited by Magelhaens. Some navigators say that they have seen among them persons nine or ten feet high, and in the last century Captain Byron, who was nearly six feet high, tried to measure one, and found that when on tiptoe he could but just reach with his hand the top of the Patagonian's head. There are not wanting other witnesses to confirm this account. Though the most modern navigators have not met with persons of such a size, Captain FitzRoy states, that he has nowhere met with an assemblage of men and women whose average height and apparent bulk approached to that of the Patagonians. Among two or three hundred of them scarcely half-a-dozen men are seen whose height is under five feet nine or ten inches, and the women are tall in proportion. Their heads and features are large, but their hands and feet are neither so muscular nor so large-boned as their height and bulk would induce one to suppose; they are also rounder and smoother than those of white men. Their colour is a rich reddish-brown, between that of rusty iron and clean copper, rather darker than copper, but not so dark as good old mahogany. Nothing is worn upon their head except their rough, lank, and coarse black hair, which is tied above the temples with a fillet of plaited or twisted sinews. Large mantles made of skins sewed together, loosely gathered about them, hanging from the shoulders to the ankles, add so much to the bulkiness of their appearance, that one ought not to wonder at their having been called gigantic. They paint their bodies with black, red, and white paint, with which they make grotesque ornaments, such as circles round their eyes, or great daubs across their faces. On their feet are boots made out of the skins of horses' legs. Wooden spurs, if they cannot get iron, sets of balls united by thongs, called *bolas*, and a long tapering lance of bamboo, pointed with iron, complete their equipment. The women are dressed and booted like the men, with the addition of a half-petticoat made of skins, if they cannot procure foreign coarse cloth. They clean their hair, and divide it into two tails, which are plaited, and hang down one on each side.

Their huts are in shape not unlike gipsy-tents. Poles are stuck in the ground, to which others are fastened, and skins of animals sewed together form the covering, so that an irregular, tilt-shaped hut is thus made. Three sides and the top are covered; but the front, turned towards the east, is open. These huts are about seven feet high and ten or twelve feet square; they are lower at the back or western side by several feet. They have no other furniture but their arms and hides to sleep on. Among their arms the balls or bolas are the most formidable. They consist of two or three round stones, lumps of earth hardened, iron or copper ore, or lead. These balls are connected with one another by thongs equal to one another in length, with their inner ends united. Taking one ball in the right hand, the other two are whirled round several times, and the whole then thrown at the object to be entangled. They do not strike the objects with these balls, but endeavour to throw them so that the thong shall hit a prominent part, and then of course the balls swing round in different directions, and the thongs become so twisted, that struggling makes the captive more secure. A powerful missile is formed of a single ball, similar in substance and size to the others, but attached to a slighter rope about a yard long. Whirling this ball, about a pound in weight, with the utmost swiftness round their heads, they dash it at their adversary with almost the force of a shot. At close quarters it is used with a shorter scope of cord as a very efficient head-breaker.

The principal subsistence of the Patagonians is the flesh of mares, ostriches, cavies, and guanacoes; but though they are not particular, and eat almost anything that they catch, the flesh of young mares is preferred to any other. They broil or roast their meat, and eat it with a lump of fat and salt. They eat also two kinds of roots growing wild in their country, after having roasted or broiled them. Dogs are kept for the chace, but not eaten, nor are horses, unless disabled by accident. In some parts cattle are rather numerous; but their flesh is not thought equal to that of mares.

They do not cultivate any kind of plant or vegetable, and are remarkable for uniting more closely together than other nations the occupation of herdsmen and hunters. To this circumstance, probably, it is to be ascribed that none of their tribes claim an exclusive right of property to any part of the country, and that they traverse the whole plains freely and without any prejudice to others between 40° and 52° S. lat. They are much given to this wandering life, and travel with great expedition. The same tribe has been found in September on the shores of the Straits of Magelhaens and in the following February on the banks of the Rio Negro, distant nearly a thousand miles from one another. It is, however, probable that those tribes which have cattle do not remove far from the places affording pasture-ground for these animals, which are not frequent, and only met with in some parts of the country. Travelling appears their principal occupation, and hunting is occasionally resorted to when there is a scarcity of food. The whole tribe then collect together, surround a considerable tract of country, and kill with the bolas all the animals thus enclosed. They have dogs to assist them in their hunting. The produce of the chace is divided among the different families, in proportion to their numbers.

The Patagonians have more exclusive ideas of property than the native tribes in the woods of the Amazonas. Among them are rich and poor people. Their wealth consists chiefly in horses and dogs, the richer individuals having forty or fifty horses and a large number of dogs, the poorer only one or two horses and but one dog. But respecting other objects their ideas of property are less fixed. When, for instance, one family has eaten its share of the chace sooner than others, any one that is hungry goes to a party which has meat left, and cuts off what is wanted without a question. Their ideas and usages also show that they have attained a higher degree of civilization than the native tribes of Brazil. They have a multiplicity of deities, some good, some evil, and believe that the first reside in vast caverns under the earth. When these good deities made the world, they first created the Patagonians in the subterranean caverns, gave them the lance, the bow and arrows, and the balls, and then turned them out to shift for themselves. They imagine that the deities of the Spaniards created them in the same manner, but that, instead of lances, bows, &c., they gave them guns and swords. They say that when the beasts, birds, and lesser animals were created, those of a more nimble kind came immediately out of the caverns; but that the bulls and cows being the last, the Patagonians were so frightened at the sight of their horns, that they stopped the entrances of the caves with great stones. Therefore they had no cattle in their country until the Spaniards, who, more wisely, had let them out of their caves, brought them over. The Patagonians have also an idea of immortality, for they think that their souls go to the caves to live there with the deity who presides over their particular race. They have also a kind of religious worship, but this is entirely directed to the powers of evil.

Marriages are more frequently made by sale than by consent. Inclination may sometimes determine the choice, but payment must in every case be made in proportion to the supposed value of the damsel and the property of the purchaser. Each man has commonly only one wife, but a few, who have forty or fifty horses and other riches in proportion, have four or five wives. The women are very faithful and laborious. Their lives are one continued scene of labour; for besides nursing and bringing up the children, they are obliged to do most of the drudgery. Except hunting, providing food, and fighting, all work is done by women. Man and wife seldom forsake each other, even in extreme old age. The husband rarely beats his wife; but their passions, unrestrained by civilization, occasionally run extremely high, and at such times they spare nothing in their fury. They take great care of sick persons, and show much attention to old age.

Their caciques or chiefs are hereditary, but their authority is very limited. In cases of importance they are assisted by a council of the principal individuals and wizards. They have not the power of raising taxes or of taking anything from their vassals, but are, on the contrary, obliged to treat them with great humanity and mildness, and often to relieve their wants, or they will seek the protection of some other chief. For this reason many who are born caciques refuse to have any vassals, as they cost them dear, and yield but little profit. No individual or society, however, can live without the protection of a cacique, according to their law of nations, and were any to attempt to do so, they would undoubtedly be killed, or carried away as slaves, as soon as discovered. The prerogative of the cacique consists chiefly of his power as a magistrate and judge, and he may punish as he pleases, even with death, without being answerable for it. He it is, also, who gives directions to encamp, march, travel from one place to another, to hunt or make war.

The Patagonians, like the Jakutes in Siberia, do not appear to be very sensible to heat or cold, if we may judge from their habits of life and from their clothing. The only difference in their dress during the winter is that they more constantly wear horse-hide boots. In summer their feet and legs are generally naked. They are not of a quarrelsome disposition. The wars between the single tribes are not frequent, and never last long, nor are they carried on with cruelty. They are friendly to the crews of the vessels which visit their shores. Europeans commonly regard them for some time with distrust. This is owing chiefly to the singularly wild look which characterises all uncivilized tribes, and which is particularly conspicuous in the Patagonians; but of all savage nations, perhaps, these tribes are least inclined to attack or deceive strangers.

North of the Pampas of Patagonia are the *Pampas of Buenos Ayres*. They extend from 40° to 34° 30′ S. lat., and reach from the shores of the Atlantic to the foot of the Andes. Though in general a plain, their surface exhibits in several parts a considerable degree of variety. That portion of it which lies east of 61° W. long. is far from being level, but all the inequalities of its surface are too inconsiderable to be called hills, except in the southern districts, where several ridges of high land with flat tops occur, which run from south-east to north-west, and lie in two lines, with, however, many interruptions in their continuity. A great portion of the country lying between the two lines of hilly ridges, as also a very large tract north of the northern line, are covered with swamps thickly set with canes and reeds, and interspersed with numerous but shallow small lakes and ponds. This country resembles the better part of the Cambridgeshire fens, and would, if drained, afford excellent pasture-grounds. These fens owe their existence to the flatness of the surface, and to the numerous streams whose waters cannot make their way to the sea, or the rivers in the vicinity, for want of a sufficient descent. These swamps do not extend to the banks of the river Salado, which are firm, and are even at present used as pasture-grounds. North of that river the plain is only broken by ascents and descents so slight as to be almost imperceptible, and its whole surface is covered with luxuriant coarse grass, growing in tufts, and partially mixed with wild oats and trefoil. Extensive tracts are entirely overgrown with thistles from six to eight feet high, which are used for fuel, as the country is entirely devoid of trees and shrubs. Near the dwellings of the inhabitants are small plantations of peach-trees, also used as fire-wood. The depressions of the surface are numerous but shallow, and in them the water collects during the rains and forms pools. This evaporating after a continuance of dry weather, the depressions become covered with rich grass, which supplies pasture during the dry weather, when the grass of the higher grounds has been parched up by the heat. Thus their country is able to maintain immense herds of cattle and horses. When pastured the coarse grass and thistles gradually disappear, and are replaced by a fine and thick turf. The soil, however, is not less fit for agricultural purposes, and in recent years abundant crops have been obtained from it, especially of wheat. It is certainly a drawback that the water of all the rivers is salt, especially in summer, when their volumes are much diminished. This appears rather remarkable, as it is stated that the country which they drain is not impregnated with saline matter, for fresh water is found at no great depth under the surface almost everywhere, and thus wells are easily dug. As the population of this region is composed of agriculturists of Spanish origin, nothing particular is found in their character, manners, or practices which deserves to be noticed.

The western portion of the Pampas of Buenos Ayres is divided into a pastoral and an agricultural district, separated from each other by a line not much differing from the meridian of 66° W. long. The pastoral district is east and the agricultural west of that line. In the country which surrounds the sources of the Rio Salado, the soil of the plain begins to be impregnated with saline matter, and continues more or less so to the base of the Andes. Its surface may be called a dead level, as the depression and elevation are imperceptible to the eye; but that such depressions and elevations exist is evident by the state of the country after the rains, for the lower grounds are then found covered with extensive saline swamps overgrown with reeds, and where the swamps are very shallow they are encrusted with a saline efflorescence. The more elevated tracts intervening between these swamps are clad with a coarse grass, which attains a height of six feet, and resembles rye or wild oats. The grass occurs in clumps, and is salt to the taste. In every part of this larger tract are shallow lakes containing salt water, and some of them are from ten to twenty miles long, and nearly as wide. One shallow depression occurs of such an extent that it is fifty miles long, and twenty wide. During the rains, when several small rivers flow into it, this is converted into a temporary lake; but towards the end of the dry season the evaporation has carried off nearly the whole body of water, which is then only found in numerous small ponds interspersed within the depression. The soil is stated to be good, consisting of a dark friable mould without a pebble. The most remarkable feature of this extensive country is the total absence of permanent water-courses. After a continuance of heavy rains, or when the rivers rising in the Sierra de Cordova are filled by the melting of the snow, they reach the plain lying south of them, but their water is spread over the depressions above noticed. These rivers, however, cease to flow in the dry season. Next to this the absence of trees is the most striking peculiarity. A few copses of small trees, mostly peach planted for fuel, and some small groves near the habitations of the inhabitants, are all that are found. It is difficult to discover a sufficient reason for this deficiency, as the country is covered with a great depth of alluvial soil, and as trees are abundant in most of the adjoining districts. Several causes probably concur in preventing their growth: the furious storms which sweep along the level surface; the want of water during a part of the year, which is sometimes so prolonged as to become a severe drought; and the numerous herds of wild cattle which range over the plains, and eat up every leaf which retains any moisture during the dry heat of summer. The salt with which the soil is generally impregnated cannot account for their universal absence, as trees are not found in places where such is not the case. Besides, it is an ascertained fact that trees grow in the saline districts where they are planted and partially sheltered.

This portion of the western Pampas of Buenos Ayres, as well as the whole of the eastern, appears to be one immense bed of alluvium; and scientific men have endeavoured to explain in what way this alluvium has been formed. Most of them incline to the opinion that it has been tranquilly deposited by waters which have originated in the Andes, and have flown with a gentle course to the Pacific. That may have been the case. What, however, renders this thick stratum of alluvium most remarkable is the circumstance that the fossil remains of gigantic animals, of long lost species, are here found imbedded, such as those monsters which have been named by our naturalists megatherium, mastodon, glyptodon, &c. These fossils are also much more common than was supposed; and when carefully sought after are found at numerous places during the dry season, or after long droughts either in the banks of the rivers or in the beds of the numerous lakes which are then dried up. None of these now extinct species appear to have been animals of prey, but all herbivorous. It is also remarkable that no skeletons of animals now living in these regions have yet been discovered in this alluvium.

The climate of these plains is also distinguished by several peculiarities, at least when compared with European countries. The cold of the winter is not much experienced in the town of Buenos Ayres, where the thermometer does not usually descend below 36°, and very rarely to 28° or 29°; but in the Pampas, and at some distance from the sea and the river Paraná, it descends every year below the freezing-point for several nights together, and occasionally several degrees. On the other hand, the number of dry days in the capital is but small in comparison with those which are rainy; but in the plains the summers are commonly very dry, rain not falling for many days and weeks. Sometimes several months pass without rain: during these droughts numbers of cattle die for want of water, and at some places for want of food, as the grass is entirely dried up. But the most remarkable phenomena are those hurricane-like storms which are known by the name of *pamperos*. They occur in summer after a continuance of northern wind and of sultry weather. Before the setting-in of the storm, clouds gather in the south-west, which soon assume a singularly hard and rolled or tufted appearance, like great bales of black cotton, and are continually altering their forms. They are followed by gusts of hot wind, blowing at intervals of about a minute. Then suddenly the storm, which apparently proceeds from the snow-capped summits of the Andes, rushes down with an undescribable violence, sweeps over the Pampas, and ere it reaches the town of Buenos Ayres often becomes a hurricane. The pampero is frequently accompanied by clouds of dust, collected from the parched-up soil, so dense as to change the brightest light in an instant, as it were, to the most intense darkness, so that people are unable to find their way. Instances have occurred at Buenos Ayres of persons bathing in the river being drowned ere they could find their way to the shore. These clouds are often attended by a heavy fall of rain, which, mingling with the dust as it pours down, forms literally a shower of mud. Sometimes the pampero is accompanied with the most terrific thunder and lightning, doing great damage, and frequently attended with loss of life. The shipping in the La Plata river always suffers greatly from a pampero, and the loss of property is considerable. The force of these storms must be immense, as it is able to remove heavy bodies to a great distance. Captain FitzRoy mentions that a small boat, before the setting-in of the storm, had been hauled ashore just above water-mark, and fastened by a strong rope to a large stone; but after the storm it was found far from the beach, shattered to pieces, but still fast to the stone, which it had dragged along.

When the Spaniards took possession of these plains they were pastured by large herds of guanacoes or llamas; but these animals have nearly disappeared, giving way to cattle and horses, which are now found there in great numbers. Some writers say that there cannot be less than one million of cattle, and three millions of horses. Some other wild animals, however, have kept their footing. The most remarkable is the emu, a kind of ostrich, the chace of which affords quite as much amusement to the wild *Gaucho* as hunting the fox to the sportsman in England, and the horses are trained to pursue it in all its shiftings and mazes. The Gauchos hunt them for their feathers, and use for that purpose the bolas. The hunters whirl these balls round their heads while in pursuit, and throwing them at the bird when sufficiently near, they twist round its legs and bring it to the ground. There are numbers of small deer in these plains, but as their flesh is not much esteemed by the natives they are not molested. The biscacho, an animal between a rabbit and a badger, is peculiar to these plains, in which it burrows more or less in every direction, so as to render travelling dangerous, particularly by night, their holes being so large and deep that a horse is almost sure to fall if it steps into one of them. Their flesh is much relished by the people, and they are hunted with dogs, against which however they defend themselves for a considerable time. The armadillo is also found, and is in great esteem among the natives for its flesh.

After the Spaniards had got a firm footing on the banks of the Rio de la Plata, the native tribes, resembling the Patagonians in their roving propensities and manners, left the neighbouring countries, and the Spaniards dispersed over the plains. As they found the pasture-grounds, as it were, boundless, they abandoned the idea of cultivating the ground, and formed numerous cattle-farms at great distances from each other. Although these settlements are frequently attacked by the savage tribes, they have continued this manner of life for nearly three hundred years. This has impressed on their character, habits, and costume, such peculiar features that they are considered as a distinct nation, and distinguished by the name of *Gauchos.* These people may be said to live on horseback, for they never move a hundred paces from their habitations without mounting a horse, one always standing saddled before the door. A Gaucho is clad in the *poncho*, which is manufactured by the women. It is about the size and shape of a small blanket, with a slit in the centre to admit the head. It therefore serves to keep out the wet and wind, and leaves the arms at perfect liberty. The poncho was originally an Indian garment, and is generally made of wool, beautifully interwoven with colours. It is sometimes worn slung across the shoulders, sometimes as a belt, but is always used for a blanket at night. The jacket of the Gaucho resembles the jackets worn by the Spanish peasantry, and is made of coarse cloth or baize, or of velveteen; his breeches, made of the same materials, are open at the knees. His leggings are composed of horse-hide, and his toes are left bare. A straw hat, with a cotton handkerchief tied round his face, complete his dress. He is always armed with the bolas, which were mentioned before, and the *lasso.* The lasso consists of a rope made of strips of untanned hide, varying in length from fifteen to twenty yards, and about as thick as the little finger. It has a noose or running knot at one end, the other extremity being fastened by an eye and button to a ring in a strong hide-belt bound tightly round the horse. The Gaucho gathers the lasso in a coil before he discharges it. The coil is grasped by the horseman's left hand, while the noose, which is held in the right hand, trails along the ground, except when in use, and then it is whirled round the head with considerable velocity, during which, by a peculiar turn of the wrist, it is made to assume a circular form, so that when delivered from the hand the noose preserves itself open till it falls over the object at which it has been aimed. It is astonishing with what dexterity the Gauchos use both the bolas and the lasso, on horseback and at full gallop, and how they hit with unerring precision the object aimed at. They use them, especially the lasso, not only in hunting, but also in catching the cattle and horses which wander about the plains in an almost wild state. A long carving-knife, about fourteen inches in length, placed in a leathern sheath, which is stuck in his girdle or leggings, complete the Gaucho's equipment, and thus mounted on his good steed he is lord of all he beholds. He owns no master, tills no ground, hardly knows what a government means, and does not care for it. His wants and desires are few, and he has always within his reach wherewith to satisfy them. A Gaucho on horseback affords a noble sight. His elevated head, his upright and graceful air, the rapid movements of his well-trained steed, all concur to convey a true picture of a man perfectly independent. He resembles more a Tuarick of the Sahara than a Spaniard: thus similar circumstances form similar characters both in nations and in single individuals.

The huts of the Gauchos are small and square, with a few posts for uprights, and wattled with osier-twigs plastered over with mud, and sometimes merely protected by hides. The roof is thatched with straw or reeds, open in the centre to permit the smoke to escape. A few blocks of stones, or the skull-bones of horses, serve for seats; a small table, about eighteen inches high, to play cards upon; a crucifix hung on the wall, and sometimes an image of St. Antonio, or some other patron saint, complete his furniture. Sheep-skins for the women and children to lie upon, and a small fire in the centre, are his only luxuries. The Gaucho, when at home, is either sleeping or gambling. A few fruit-trees are occasionally planted near the hut.

The Gaucho women dress in chemises of coarse cotton, and petticoats of baize or blue cloth; their arms and neck are left bare. When they ride out they wear scarfs or shawls made of baize of a brilliant colour, and men's hats, either of straw or woollen. They sit sideways on horseback, and are as good equestrians as the men. The women are the labourers. It is they who cultivate a little Indian corn, which serves them for bread; they also raise water-melons and onions, and weave coarse baize and ponchos; but their lives are idle on the whole, and they are more remarkable for dirt than cleanliness. Their cooking utensils are usually of clay, and their platters of wood.

The western part of the Pampas of Buenos Ayres, or that which extends between 66° W. long. and the base of the Andes, presents a less level surface. The soil consists of loose sand impregnated with saline matter, and is entirely unfit for the growth of grass. The vegetation is limited to low thorny trees, standing isolated and at considerable distances from each other, some resinous bushes, and barilla plants. This country in its natural state is not unlike some tracts of the Sahara. But this arid soil, when irrigated, is changed into the most fertile fields. The saline matter, as it seems, when applied to a soil so light, becomes by the assistance of constant moisture a most active stimulant to vegetation, and serves as a never-failing manure. It is fortunate for this region that it is drained by several rivers, and that their levels are so little depressed below the general surface of the plain, that their water can be applied to irrigation without any great labour and expense. Indian corn and wheat are grown to a great extent. The soil seems particularly adapted to fruit-trees, and plantations of vines, figs, peaches, apples, olives, and nuts, are very numerous and extensive.

The rivers which water this country deserve a particular notice. They constitute a separate system of drainage, which is not connected with the sea, nor with any rivers which run to the ocean. Such closed systems of drainage are found at several places on the globe, but they are usually of small extent. The system we are now speaking of, however, is so considerable, that only one is found, in the centre of Asia, comprehending a larger space of the globe. The rivers of the Pampas, which constitute this remarkable system of drainage, rise in the Andes between 31° and 36° S. lat. They run eastward, and when they have traversed a considerable part of the plain, they unite their waters in three groups of lakes, which from north to south are called Guanacache, Bevedero, and Urre Lanquen. These lakes are placed at various levels above the sea, the most northern being the highest, and the most southern the lowest. Thus it happens that a river, the Desaguadero, runs from the lakes of Guanacache to those of Bevedero, and another, the Rio Salado, from those of Bevedero to Lake Urre Lanquen. All these lakes, however, have salt water, and their margins during the winter and spring are covered with incrustations of that mineral. Some of the rivers are also brackish, and their waters cannot be applied to irrigation, but others have fresh water, and to these the country owes its fertility and abundant crops.

In the middle of the great plain, the southern part of which has just been described, a mountain-system of small extent is found. It is called the Sierra de Cordova, from a town built near its eastern base. It occupies from south to north about 120 miles, lying between 32° and 30° S. lat., and from east to west about 50 miles, so that its area does not exceed 6000 square miles. This mountain-system is composed of several ridges running south-east and north-west. These ridges are flat on the top, which is clad with fine grass and affords good pasture. The greater number of the valleys between them are fertile, and partly cultivated, being partially covered with plantations of vines and fruit-trees. The ridges do not rise to more than 2500 or 3000 feet above their base, consequently snow does not fall on them except during two or three months. If the mountains rose to a greater height, and were covered with snow the greater part of the year, they would supply the adjacent countries with running water all the year round, and would convert them into agricultural districts. Still, even as it is, it is evident that the pastoral pampas above mentioned as the country of the Gauchos, derive great advantages from the snow which falls on the Sierra de Cordova. For the water which in winter time covers the lower tracts of the country and converts them into temporary swamps, is brought down by the streams, which in summer are dry, but by the melting of the snow have their deep beds so filled that they resemble large rivers. The grass which grows in the swampy grounds when the water has been evaporated by the long drought of the summer, affords subsistence to the cattle during that portion of the year when everywhere else the grass of the pasture-grounds has been parched up. Without these low pastures all the herds of cattle and horses would perish, and the whole country become as uninhabitable as is that portion of the great plain which lies contiguous to the Sierra de Cordova on the north. For by a peculiar disposition of the mountain-ridges all the waters collected within them run off either to the south or to the east, fertilizing these parts in a greater or less degree, but none of its numerous though scanty water-courses descend to the north or west, and those countries have remained useless wastes to this day, and will probably always be found to be so.

The northern and worst part of this plain is known by the name of *Las Salinas*, or the Salt Desert. The only traveller who has traversed this tract and given an account of his journey, Mr. French, describes it as follows:—"The morning was ushered in by a cloudy mist, through which the red sun gradually rose, partially dispersing the upper vapours, while others appeared to resist his influence, and, attracted to the earth, remained dense and motionless near its surface. As we entered the Salinas the scene became novel and striking. The wide plain, level and smooth as a floor, and snow-white with superficial salt, stretching its treeless and shrubless waste on all sides to the horizon, unbroken by any object, save a few stunted, straggling, and leafless alkaline bushes, the black and crooked branches of which, contrasting with the whiteness of the soil, were here and there hid and intersected by a broad, compact, and very thin stratum of mist, whose under-surface was slightly elevated from the soil, while its upper was below the tops of the bushes, thus permitting only their stems and tops to be recognised. This was the *mirage*. Over head rolled thick and broad masses of transparent white vapour, which, except at intervals, hid the sun without greatly intercepting his light; and when his rays shot between these masses, they were reflected from the space on which they fell by the saline superficies of the soil with a dazzling effulgence. Such was the appearance of the vast salt plains at the time we crossed them, in the middle of April. Great changes, however, are produced by a variation of circumstances. I have myself observed the most astounding change in the appearance of a portion of the plain after sudden rain succeeded by a hot sun. In a region where a slight saline efflorescence is ordinarily seen, the ground became almost snow-white from the rapid crystallization of saline matter, and reflecting the rays of a fierce sun, rendered it most difficult to keep the sight fixed on the road-track. The landscape appeared in one blaze of reflected light; trees and shrubs seemed on fire, and the whole scene might have been taken for the land of the genii; while the hot north wind, called the *sonda*, rose by degrees and in squalls to a gale, with a close heat, like that of a furnace. In this instance nothing in the shape of a cloud or mist was present." The same traveller found the plain, on approaching the Andes, in part overgrown with wood, and in part without trees and even shrubs; and observes that the most remarkable feature of this region is the great scarcity of water and the total absence of grasses, particularly of the kinds fit for cattle. Over tracts, wooded or unwooded, not a blade of grass is to be met with. All these countries, which are distinguished by the name of *traversias*, have a very dry air, and are characterized by great aridness. In some parts of them rain has been known not to fall for eighteen months. Dews are entirely unknown. The slight humidity afforded by the general state of the atmosphere appears to be drawn off towards the Salinas, and absorbed by its saline soil, which thus exhausts the atmospheric moisture, so as to render unproductive of grass regions possessing a soil favourable for its growth. The Salinas are almost the only places in which, under ordinary circumstances, any moisture is apparent, and in these vegetation becomes extinguished by the excess of nitric and muriatic salts, with the exception of a few scattered saline and alkaline shrubs.

It is doubtless to be ascribed to the vicinity of the Salinas, that Santiago del Estero, which is built on the banks of the Rio Dolce in their vicinity, experiences a greater degree of heat than any other place in America, though that town lies without the tropics (28° S. lat.). The month of December is always excessively hot, but this heat is sometimes greatly increased by a hot wind blowing from the Salinas. It blisters the skin on the face and hands even of those who remain in-doors. Leaves fall scorched from the trees, and the bark of several of them become cracked and shrivelled, just as if the heat of a fire had been applied. Even at night the locks, bolts, and keys of apartments are so hot that they cannot be retained in the hand, and it is hardly to be comprehended how they can have acquired such a degree of heat without artificial aid. The description which the inhabitants give of their sufferings and their feelings, under the apprehension of suffocation, are quite appalling.

The Salinas extend about 200 miles from east to west, and 140 miles in the opposite direction. Here, therefore, in South America, is a tract of country, as extensive as Ireland, which may be compared with the worst part of the Sahara. It is certainly a most remarkable circumstance that, north of this desert plain, the country rises into hills, which gradually attain the elevation of mountains, and, at a distance of about seventy miles from its northern border, reach above the snow-line in the

Sierra de Aconquija. Several rivers originate in this mountain tract, but they have very little water, and are lost in the ground on approaching the Salinas. It appears that the great aridness of the atmosphere, incumbent on the desert and the adjacent regions, prevents the collection of any large quantity of water in the mountains.

What a contrast with the Salinas is afforded by another desert, which lies only about two hundred miles north of it, and called the Despoblado, or the Uninhabited Country! This is an extensive plain, occupying the very top of the Andes, and stretching from east to west between 63° and 68° W. long., more than 250 miles, whilst its width gradually increases to 150 miles at the places where the mountain-masses descend towards the Pacific. The elevation of this plain has not been determined, but it is very probable that it rather exceeds than falls short of 13,000 feet above the sea-level. As in these parts of South America the snow-line appears to occur at an elevation of about 14,500 feet, the surface of the Despoblado is only 1500 feet below it, and consequently above the line where trees and bushes grow. This region is divided from south to north by a deep valley, through which the road runs which serves as a line of communication between Buenos Ayres and Bolivia. This valley has been an object of admiration to all travellers who have passed along it, on account of its great length, comparatively small width, and the steepness with which the rocks rise on both sides. It is more than 150 miles long, and at many places hardly a furlong wide. Nearly in its middle the town of Jujui is built. North of that place the bottom of the level rises gradually until it attains the elevation of 12,000 feet above the sea, where it is shut up by a transverse ridge, the Abra de Cortaderas, which unites the two portions of the mountain-plain. The eastern and smaller portion is called the plain of Yavi, and the western and larger bears properly the name of Despoblado. The degree of cold which a traveller experienced in June during a storm, accompanied by snow, hail, and sleet, on the plain of Yavi, can hardly be surpassed by that which persons have to endure who spend the winter at the North Cape, and the climate of the Despoblado is certainly not less severe. These plains are, however, not uninhabited. Several small hamlets are found on them ; in each of them reside a few families of natives, who belong to the race of the native Peruvians. They have no cultivation nor domestic animals, except llamas. But on the plains are numerous herds of alpacas, vicuñas, and guanacos, as also that little beautiful animal, the *chinchilla*. This last is so common that thousands of dozens of its skins are yearly collected and sent down to Buenos Ayres for exportation to Europe. The inhabitants collect also considerable quantities of gold, which is found in some of the alluvial deposits after heavy rains. They also bring snow to the places situated in the valley of Jujui, where it is used for making ices in the summer season. But one of the most curious features of the Despoblado is its extensive plains of salt, and they afford great advantages to the poor inhabitants, who resort to them when the salt is hard and dry, and cut large blocks of it with hatchets, with which they load their llamas, and carry them to Jujui and Salta, and other parts of the country. The eyes of travellers obliged to traverse these inhospitable wilds are said to be as much affected by the glare of the sun reflected from these fields of salt, as from the snow-capped mountains which surround the plain. The Despoblado lies for the greatest part of its extent within the tropics, extending between 22° and 24° S. lat.

SECTION XIV.—THE LLANOS.

THE forest-desert of the Amazonas extends northward until it is succeeded by the Llanos (plains) of South America. These plains have a surface as level as the most even part of the Pampas; but as they are situated within the tropics they present a wide difference in climate, soil, productions, and the life of man. Their extent, however, is much less than that of the Pampas, as their area amounts only to about 350,000 square miles, and is not quite equal to twice the extent of France.

The Llanos are situated on the left banks of the Orinoco, one of the largest rivers of South America. This river, whose source has not yet been visited by Europeans, rises in a mountainous country situated only three or four degrees from the equator, on the northern side of the line, and flows first westward for about 350 miles, then northward for nearly the same distance, and lastly eastward for nearly 500 miles. Its course describes nearly a semicircle, and its mouths are found to lie to the east of its source, though the direction of its upper course is westward. This river is navigable as far as it is known, except a space of about forty-five miles between 5° and 5° 40′ N. lat., where the *rundales* of Maypures and Atures break the continual smoothness of its current. These rundales are cataracts of a peculiar description. The great volume of water brought down by the river does not descend at once from a considerable height, as in the Niagara river, nor does it, as in the Amazonas in the Pongo de Manseriche, traverse a narrow opening between high rocks, but the bed of the Orinoco at Maypures and Atures, where it is nearly 8500 feet wide, is divided into numerous narrow channels by rocks and rocky islands, between which the water runs with great rapidity, and forms a succession of small cascades. The highest of these cascades does not exceed nine feet, and the river descends, in about six miles, only about thirty feet by all the cascades of the rundales of Maypures; but the velocity with which the confined body of water runs in the narrows precludes the possibility of ascending the cataract. The Randali of Atures is only half a mile long, and of a similar description.

About 130 miles from the place where the waters of the Orinoco mingle with those of the Atlantic, the river divides, and sends off its waters in several channels, which again split on approaching the sea, so that the waters of the river enter the ocean by a great number of mouths. Ten of these mouths are wide rivers, and deep enough to be navigated by large vessels; but the most southern arm, called the *Boca de Navios*, contains the largest volume of water. It is divided, for a distance of about forty miles, into two channels by a series of islands which lie nearly in the middle of the stream. Each of these channels is more than two miles across, and the whole width of the river, inclusive of the islands, considerably exceeds five miles. Farther down, its breadth continues to increase, and at the mouth the river is more than sixty miles across.

The country which is included within the several mouths of the river, extending about 130 miles from east to west, and nearly 100 miles from south to north, is the delta of the Orinoco. This tract is entirely inundated during at least six months of the year, when the volume of water has increased to such an extent in the river that its wide and numerous channels cannot contain it; it then spreads over the adjacent lands, and all the tracts which lie between the different channels. In the other six months, when the water has retired to the bed of the river, its banks are several feet above its level, and dry; but farther inland the ground is not entirely drained, and the largest portion of the tracts between the arms of the river are little better than swamps. Though the delta of the Orinoco is entirely inundated during one half of the year, and almost a continual swamp during the other half, it is not uninhabited. A native tribe (the Warrows, or Guaraunos) has established itself in this region. It lives partly on the produce of its fishery in the arms of the river, and partly on the fruits of the fan-palm; for though the delta of the Orinoco, like the country on the banks of the Amazonas, is covered with uninterrupted woods, there is this difference, that the woods of the delta are almost entirely composed of one species of tree (the fan-palm), which by a Spanish author has been called the tree of life, because it supplies both food and clothing. The pith of this tree gives a kind of flour, of which bread is made; its head is eaten as a vegetable; from its fruit a kind of wine, of an acid taste, is extracted; the fibres of its leaves are used as thread, of which hammocks, baskets, and tissues for dress are made; its wood is used in the construction of their huts, which are thatched with the entire leaves of the tree. During the inundations the Warrows live on scaffolds, which are erected between the trunks of the high trees several feet above the usual level of the water, which circumstance has given rise to the opinion that this tribe lived in trees. These Indians have acquired, by long habit, a great facility in running over muddy lands, where other persons sink up to their knees; and by this peculiarity they have preserved their independence, as none are inclined to follow them in their retreats. They are good seamen, and do not possess that ferocity of character by which most of the tribes on the Amazonas are distinguished.

The delta of the Orinoco is the only portion of the plains we are now noticing which is wooded: all the remainder of this extensive region is devoid of trees. Contiguous to the delta is that portion of the plains which is called Llanos Altos, or elevated plains. It extends from the northern banks of the Orinoco northward, and reaches the shores of the Caribbean Sea on both sides of the town of Barcelona; but farther to the east it is divided from that sea by the mountain region called Sierra del Bergantin, and farther west by the coast range of the Andes. The Llanos Altos extend about 350 miles from east to west, and more than 200 miles from north to south. They are less level than the remainder of the plains. Along the banks of the Orinoco they are both level and low; and the river spreads its waters, during the inundations, to a distance of many miles from its banks. Farther north the country rises, but imperceptibly to the eye; for at a distance of more than 100 miles from the Orinoco the level of the plain is not more than 500 feet above that of the sea. The rise of the country, however, is apparent from the course of the rivers, which run in beds depressed several feet below the general level of the plains. The highest part of this plain is from 500 to 800 feet above the sea, and is a complete level from 30 to 40 miles across. Towards the Caribbean Sea it descends with a somewhat more rapid declivity, but even this is imperceptible to the eye, except at a few places. The summits of the table-lands thus formed are known by the name of *mesas* (or tables), on account of their level surface. Their soil consists of sand, in many places mixed with chalk. It is unproductive; and the vegetation, even in the rainy season, is limited to a few hardy grasses covered with a kind of hair, which afford but indifferent pasture. The rains, which fall in abundance from April to July, do not impart fertility, as on the other portions of the Llanos, because they quickly find their way through the upper layers of the soil until they meet an argillaceous chalk, where they collect and form springs and rivulets. The mesas themselves are always without water, and the traveller must perish of thirst on these high grounds if he does not carry water with him; yet these very table-lands give origin to a hundred rivers, which run off on all sides. To the greater part of this region nature has denied the power of producing grain and edible vegetables; only its southern and northern borders, along the banks of the Orinoco and the shores of the Caribbean Sea, are cultivated, and those only at a few places, where cotton, coffee, cocoa, sugar, tobacco, and several tropical roots and fruits are raised, with cassada, yams, bananas, &c.

The larger and more level portion of the Llanos extends from north-east to south-west, and lies along the base of the elevated rocky masses of the Andes, from 9° N. lat. to the equator, where it is stated to terminate on the upper course of the Yapurá, an affluent of the Amazonas. Though placed at a greater distance from the sea, they are much lower than the Llanos Altos. The lowest tract is found near the junction of the river Apure with the Orinoco. Its level is only 224 feet above the sea, though more than 500 miles distant from the ocean, to which the waters collected on it descend. To the south, however, and to the west, the country ascends imperceptibly; but it is supposed that at no place does it rise more than 300 feet above the lowest tract just mentioned. These plains are so level that the currents of the Apure and Meta rivers, in their lower course, are imperceptible, and a strong eastern gale, or the least rise in the Orinoco, causes their waters to flow back. The native tribes who navigate these rivers maintain that, in proceeding from the Orinoco up these rivers, the first day's voyage is with the current. In these plains no rock, no stone, nor even a pebble is seen. They are covered with grass, but entirely destitute of trees and bushes, except a number of isolated palm-trees, which occur at great distances from each other. On the banks of the rivers, at many places, are thickets of low bushes; but in general no wood is seen even there. The only inequalities of the surface are some hills, merely of sand, which rise a few yards above the common level, and some slightly elevated grounds called *banks*. These banks are sometimes of great extent, having an area of 100 square miles and more; but their elevation is so small that only a practised eye can distinguish it, and their surfaces are completely flat. They are of great importance to the inhabitants, as most of them are not subject to inundation, and consequently afford places for building, and pasture for the cattle, when the lower parts are covered with water. The soil of these plains has not much depth, and consists of a mixture of sand and chalk, mixed up with some mould. The grass which it produces is very nourishing at most places, though at others the pasture-grounds are but indifferent.

In the Llanos, as in all other countries between the tropics, the year is divided between a dry and a wet season. It is very probable that the changes in the atmosphere, by which these variations in the climate are produced, are more regular in these plains than at any other part of the globe. The great extent of the plains, and their low and level surface, permit the currents of the air to develope themselves without the least obstacle. At most other places this process of nature is prevented, or at least influenced or changed, by mountains, or the vicinity of the sea, or by a broken and uneven surface. In all such places the regularity of the phenomena attending these changes is interrupted or mixed up with other phenomena, which arise from causes not connected with their regular process. It is true that along the western side of the Llanos the Andes rise to a great elevation, and at some places above the snow-line, but as these mountains extend in their general direction from south to north, or from south-west to north-east, they do not lie in the way of the principal currents of air, which depend upon the position of the sun and its march from the southern to the northern hemisphere, or in the opposite direction. It is, therefore, supposed that these mountains do not materially influence the changes of the season and the phenomena with which they are attended. The mountains of Venezuela, both the coast-range of the Andes and the Sierra del Bergantin, may certainly affect the free development of the aerial currents in their vicinity, but they are of too small extent and not elevated enough to have any material effect on a level plain which extends to nearly six hundred miles from their bases. As on these plains, therefore, the two seasons and their changes are less influenced by localities, Alexander von Humboldt has examined all the phenomena with great attention, and endeavoured to give an explanation of them.

Nothing can be compared with the purity of the atmosphere from the month of December to that of February. The sky is always serene and cloudless ; if a cloud appears, it is a phenomenon which attracts the attention of all the inhabitants. The wind blows from the east and east-north-east with force. As it brings to the plains an air which is always of the same temperature, the vapours cannot be condensed by cold, and cannot become visible. Towards the end of February and the commencement of March the blue colour of the sky is less intense, the hydrometer indicates a gradually increasing humidity of the air, the stars are sometimes enveloped in slight vapours, so that their light is not steady, but is observed from time to time to sparkle, until they rise to an elevation of more than 20° above the horizon. At this period of the year the wind blows with less force, and is less regular, being from time to time interrupted by dead calms. Clouds begin to make their appearance and to accumulate in the south-east. They resemble distant mountains, their edges being well defined. From time to time some of them are observed to rise above the horizon, to detach themselves from the others, and to traverse the celestial vault with a rapidity which is by no means in proportion to the feeble winds experienced in the lower regions of the atmosphere. At the end of March small electric explosions are observed to occur in the southern regions of the atmosphere. They appear like phosphorescent lights limited to an isolated group of vapours. Then also the wind passes from time to time, and for several hours, from east to west and to south-west. This is a certain sign that the season of rain is approaching, which actually sets in towards the end of April on the banks of the Orinoco. The sky begins to be overcast, the blue colour disappears, and is replaced by a grey coating, which has everywhere an uniform appearance. Meantime the heat of the atmosphere is continually and gradually increasing. In a short time they are no longer clouds which envelop the sky, it is a strongly-condensed vapour. During the dry season, from December to February, the electricity of the atmosphere hardly undergoes any change, varying in day-time only between one-third and two lines of the electrometer of Volta; but in the month of May it becomes very variable. During whole days it is nil, but at times, and for several hours, the elder-balls of the electrometer of Volta diverge three or four lines. The season of the rains is also that of thunder-storms. "But," says Humboldt, "a great number of experiments which I made during three years have convinced me that just during this season of the thunder-storms, the electric tension is very small in the lower regions of the atmosphere. The thunder-storms begin two hours after the sun has passed through the meridian, consequently very little time after the highest degree of heat is experienced between the tropics. It is very rare to hear the thunder during the night, or in the morning. The nightly thunder-storms occur only in certain valleys of rivers which have a peculiar climate."

The setting-in of the rains and thunder-storms takes place when the sun passes through the zenith, which occurs between 5° and 10° N. lat., between the 3rd and 16th of April, and is attended by a cessation of the north-eastern wind, frequent calms, and occasional south-western winds, accompanied by storms and an overcast sky. It appears that the first of these phenomena, the cessation of the winds, affords a clue to explain the whole process. Whilst the north-east wind blows with all its force, it prevents the air incumbent on the intertropical countries and seas from becoming saturated with vapours. The humid air of the torrid zone, rarefied by the heat, rises into the upper regions of the atmosphere, and there flows off to the poles, whilst the lower currents, proceeding from the poles, bring to these places a much drier and colder air, which continually replaces the columns of air which ascend from them. As long as this process continues without interruption, the moisture, so far from being accumulated in the countries near the equator, is carried off towards the temperate and cold regions. During the north-east winds, which blow when the sun is in the southern hemisphere, the sky is always cloudless in the intertropical countries of the northern hemisphere. The vapours do not condense, because the air is always replaced by other air far from the point of saturation. But when in progress of time the sun enters the northern constellations, the north-east wind abates gradually, and at last ceases to blow. The difference of temperature between the intertropical countries and the temperate zone is then less than at other periods of the year. This is the summer in the northern hemisphere, and the mean summer heat, experienced between 42° and 52° N. lat., is only from 7 to 10 degrees less than that of the intertropical countries, whilst in winter the mean heat differs from 36° to 46°. When the sun is in the zenith and the wind ceases, the causes which produce and accumulate the humidity of the air of the equatorial zone become more active. The stratum of air which is incumbent on these countries by degrees becomes saturated with vapours, because it is not renewed by the current from the poles. Then clouds are formed in this saturated air, by condensation produced by the combined effect of the radiation and dilatation of the ascendant air. This air increases its capacity, from being heated in proportion as it becomes more rarefied. With the formation and accumulation of the vapours the electricity also accumulates in the upper regions of the atmosphere. At last the precipitation of the vapours takes place, and the rains continue during the day-time. They cease commonly during the night, and frequently at sunset. The rains are in general most heavy a little after the greatest degree of the diurnal heat is experienced, and then they are attended by electric explosions. This state of the weather continues until the sun returns to the equatorial line, and re-enters the southern hemisphere. The atmosphere of the northern temperate zone then rapidly grows colder, and in consequence of this event the current of air proceeding from the northern countries to those between the tropics again makes its appearance, because the difference between the temperature of the intertropical and temperate countries is continually increasing. The north-east wind again blows with force, the air between the tropics is continually renewed, and cannot longer attain a high degree of saturation. The rains consequently cease, the vapours dissolve, and the sky resumes its purity and deep blue colour.

After the commencement of the rains, the waters of the rivers begin to rise, and after a few weeks, their beds are not capacious enough to hold the large volume which gathers in them. They rise above their banks, and inundate the low countries bordering on them. The inundations extend to a considerable distance from the banks of all the larger rivers, and in some cases the tracts which lie between them are entirely laid under water. There is a large tract of low country where the Orinoco changes its northern into an eastern course, which extends on both sides of the river Apure. This tract, having an area of 4800 square miles, is converted into a temporary lake, the water covering it being from twelve to fourteen feet deep. The villages and cattle-farms, which are built on small banks, are raised scarcely two or three feet above the level of the lake. Many horses which wander about in the pasture-grounds perish, being unable to get on the more elevated points of the plain when the waters are rapidly rising. The mares, followed by their foals, swim about to get to the grass, the tops of which only are above the level of the waters, and a great number of the foals are drowned because they sooner tire in swimming, and follow their mothers into water too deep for their height. When thus seeking their safety, these animals are frequently attacked by the caymans, which swarm in most of the rivers; and horses are frequently met with, whose legs are marked by the teeth of these reptiles. At this season large barges traverse the plain, where six months later numerous herds of cattle, horses, and mules, find abundant pasture.

When the waters have begun to draw off, and the rivers are again confined to their beds, the higher tracts of the plain become dry and firm, and are covered with a fine turf, interspersed with aromatic flowers. The animals, which at the end of the dry season, and during the long inundations, had become very lean, are soon in good condition. As the dry season advances, this grass attains a height of from five to eight feet, and becomes hard and unpalatable for the animals; but at that time the lower grounds, which for some weeks longer had remained in a swampy condition, are clad with a fine short grass, which is very nourishing. But towards the end of the dry season the grass becomes so extremely coarse, that it is unfit for cattle, for it then more resembles dry reeds. If this grass was to remain on the ground, it would prevent the young grass from springing from the roots of the old, as it does immediately after the first rains. It is, therefore, necessary to burn it down. To effect this the natives set fire to it at different points, producing a conflagration which extends over many square miles, and affords a magnificent spectacle when seen from a distance. The rapidity with which the volumes of fire are driven on by the wind that constantly prevails at that season in these level plains is terrific, and threatens certain destruction to every living being that is unfortunately surprised by it. There is, however, generally sufficient warning afforded by the clouds of smoke that arise from the conflagration, giving the sun a lurid appearance. In the rear of the flames, the track of which is marked by the smoking roots of grass and the blackened soil, follow flocks of vultures and *gallinazos*, which find abundant subsistence, as long as the fire lasts, in the multitude of snakes, bull-frogs, and other small animals, which have been overtaken by the flames and scorched to death. In this season, also, the caymans, inhabiting those places, which only dry up towards the end of the season, make a hole in the mud which remains, creep into it, and cover themselves with moist earth, falling into a lethargy, which only ceases when the rains set in, and fill the depressions again with water. The domestic animals fare badly for food, but still worse for drink, in such places as are distant from running streams. There are usually some places where stagnant water is still left, but the natives are too lazy to look for them; and to make a well, which is no laborious work, as the water is always found at a depth of a few feet under the surface, is hardly ever attempted. They compel the animals themselves to find out the stagnant waters, for which purpose they keep them penned up for some time, and then let them loose. The animals run against the wind with raised heads and open nostrils, and commonly succeed in finding out such places by the comparative humidity of the air in their vicinity. The asses show the greatest sagacity in this respect. In many places a kind of cactus is found, which is beset with thorns, but contains in its stem a quantity of water. The asses crush these plants, and sip its contents with caution, but many of them are lamed by the thorns.

The heat towards the end of the dry season is very great, the thermometer rising in the shade at two o'clock to 97°, and when exposed to the sun's rays to 125°. But it increases up to the month of July, when the thermometer, at two o'clock in the afternoon, ranges between 102° and 105° in the shade and fifteen feet above the ground. As the surface has lost all its moisture by evaporation, and the north-eastern wind is still blowing in March, it raises such a quantity of dust that it is almost impossible to find one's way, especially when the wind blows in whirls. The plains then offer a most sombre aspect, as the whole of them present nothing but a complete desert, consisting of brown sand, the trees and bushes having then shed their leaves, and the grass being entirely dried up: but it is stated that the trees begin to unfold their leaves before the first rains set in.

The want of wood is not felt by the inhabitants, as their climate does not render it necessary as fuel, and for their domestic uses they have a substitute in the *guadua*, or South American bamboo, which abounds in many parts, forming rather large groves along the banks of the rivers. This is a gigantic species of cane, growing to the height of ninety feet and frequently even more, with a beautiful feathery appearance. The upper part bends gracefully downward, and is covered with long slender branches, which spring from the joints, and bear very small light leaves. This cane is extremely useful for the purpose of building houses and bridges, as well as for fencing plantations, and surrounding the *corrals* or cattle-pens, as it resists the weather for many years. The thickest parts serve for posts, beams, and rafters. They are also formed into broad planks, by being split open longitudinally with an axe, and spread out by cutting through the alternate joints at sufficient distances to allow of their hanging together. In this state they answer very well for roofing and for flooring the upper story, which is that which is generally inhabited in the marshy districts. The guadua also serves for making bedsteads, tables, and benches, which are both light and neat. The walls of the houses are made of the small branches tied closely together, fastened with thin thongs of raw hide, and plastered over with clay. The thickest canes, being frequently eight or nine inches in diameter, are made into buckets by cutting off joints for that purpose. Small barrels are also made in the same way. The guadua is also in great demand for building bridges across the narrow rivers in the plains.

In no part of the world is the electric eel found in such numbers as in the numerous rivers which join the Orinoco in its middle course, and in that river itself. These animals resemble a common eel, except that they are rather thicker in proportion to their length. They are of a yellowish and livid colour with a row of yellow spots on each side from head to tail. They are difficult to catch, on account of the great agility with which they hide themselves in the mud. The Indians take them in the following way. They force a herd of horses to go into shallow water, which they know to be frequented by these eels. The noise which the horses make with their feet brings the eels out of their muddy retreat, and they immediately attack the horses, by pressing themselves beneath their bellies, and discharging on them their electric shocks. The frightened horses make efforts to get out of the water, but the Indians prevent them, and the eels repeat their discharges. Some of the horses being stunned by these repeated strokes, fall down and are drowned. Others evince all the signs of horror, and endeavour to escape, but are prevented by the Indians. At last the eels are exhausted, in consequence of the repeated electric discharges, and are easily taken. The shock which these animals communicate is so severe that it is impossible to hold them in the hand or to tread on them. They can give a shock exactly similar to that of an electric battery, stunning fish through the medium of water, and if they are small, killing them. This shock is evidently given by a voluntary act of the fish, for it is not always felt instantaneously on handling them; and the moment of the effort being made can be distinguished by the corrugation of the skin and the changing of its colour. The most remarkable of the other inhabitants of the rivers are the manatee, or sea-cow, and a kind of dolphin, whose species has not yet been determined, and which is the only one of the whole family found in fresh water. These fish are from three to four feet long, but so active that they are feared by the cayman, probably because they are only met with in large numbers, one swimming behind the other.

The wild animals are not numerous; except a kind of deer, which is very slow and not much sought after, because its flesh is not valued, and a species of agouti. The American tiger, or jaguar, and the American lion, or puma, are sometimes met with, when the grass is high, and these animals, especially the first, destroy large numbers of domestic animals. The chiguiris are a kind of amphibious river-hog, having very short ears and no tail, but in other respects resembling the pecari, or wild hog of the woods. These animals are found in droves in the marshes and on the borders of the lagoons, to which they retreat on any alarm. Their flesh is tender and fat, but has a strong fishy taste. It is stated that at present there are no wild cattle nor horses which have not a proprietor, but there are wild asses, wild hogs, and wild dogs, whose ancestors were domestic. The wild dogs have increased at some places so much as to be dangerous to small parties of travellers, being of the breed of a fleet and ferocious dog, which is much valued for protecting the cattle against the attacks of the jaguar and puma.

That part of the Llanos which is not subject to inundations was not quite uninhabited at the arrival of the Spaniards ; a few families of a native tribe having settled there, whilst others visited it occasionally. But the lower Llanos had no settled inhabitants. For the Indians, having no domestic animals except some birds of the fowl kind, were unable to procure subsistence during the six months in which the country is under water. Some Spaniards, settled in the mountainous country north of these plains, discovered them, and soon became aware of their value as pasture-grounds. In the middle of the sixteenth century they brought some horses, cattle, and asses to them, and these animals have so increased in number, that it is stated they amount at present to more than three millions. With these animals the Spaniards emigrated, and up to this time they are the only inhabitants of the Llanos, with the exception of a few families of Indians of different tribes, who have settled among them, and a still smaller number of negroes. As the descendants of the Spaniards have no other occupation but to tend the domestic animals, to kill them and dry their hides, and to break-in the horses, their number is but small. The cattle-farms are at a distance of a day's march and more from each other, to allow sufficient range without interference for their respective herds of cattle. As there are no roads in these plains, it is very difficult for a stranger to find his way from one farm to another. The inhabitants guide themselves by the clumps of palms, which are to be seen at considerable distances apart, giving the idea of small oases in the desert.

The cattle-farms are called *hatos*. The houses attached to them are built of guadua: they are of one floor, consisting in general of a large hall, the walls of which are hung round with saddles, bridles, and lassos. The furniture commonly found is limited to a large table and several long massy benches too heavy to be moved. In the hall the inmates eat when driven in by the rain, and there also the males belonging to the farm sleep in bad weather. They lie down on undressed bullocks' hides spread over the benches, but these places of rest are by no means softer than the earth. There is also a separate apartment or two for the females' use in the rainy season. In the dry season all sleep in the open air on account of the heat. The neighbourhood of the corral is preferred as a protection against the *zacudos*, a kind of gnat which is very troublesome, but prefers attacking the cows. The male inhabitants have more abandoned the usages of civilized life than the females. This is especially conspicuous in their dress. The men go stark naked, except a cloth of cotton which is wound round the loins, like the savage tribes on the Amazonas. But the women have only changed their dress so far as it is rendered necessary by the peculiar climate of the Llanos. Their food is extremely simple, consisting every day of roast beef, cheese, and milk, to which they add brandy as drink, but never in such quantities as to be inebriated. Bread is extremely rare, except on the plains bordering the higher country, where grain is cultivated. At some places on the banks of the river, however, small plantations of plantains or cassada are met with. In some parts the sugar-cane is cultivated, but though it grows well, it runs more into leaf than that planted in the hilly country, is thicker, and gives more juice, though less saccharine matter in proportion. Some is cultivated only for chewing, but in general a very coarse kind of sugar is made, and the greatest part is used for distilling that kind of spirit which is used in the country and called *aguardiente*.

As there are, of course, no inns in these plains, hospitality is exercised to the greatest extent, and a traveller resorting to a farmhouse is considered as conferring an obligation on its proprietor. His horse is immediately unsaddled and turned loose, for it is quite a matter of indifference whether they stray or not, as there are always plenty of horses close at hand, which are considered as public property. Water is then brought to wash the stranger's feet, after which he spreads his cloak or blanket in the shade, and lies down, using his saddle for a pillow. Meanwhile one of the family has already saddled a horse and set out in search of a calf or a young heifer, for which they have seldom far to ride; indeed they generally keep one tied up in the corral in readiness for daily use, as meat will not here keep good for a day after being killed. In less than half an hour an abundance of roast beef is set before the visitors, and sometimes, but very rarely in the remote cattle-farms, some bread. The repast concludes with milk, cheese, and aguardiente.

Their occupations, as well as their ideas, lie within a very narrow compass. Two or three, on horseback, look daily after the cattle, and bring those back which have gone astray; they bring also the milking cows to the corral. The other inmates of the farm are mostly idle, except in the season of slaughtering the cattle, when all are busy, either in drying the hides or in jerking the beef. The most laborious part of their business is the breaking-in of the wild horses, in which they display great dexterity, firmness of mind, and courage.

Passing their lives on horseback, the llanieros have acquired an extraordinary skill in managing their animals. In this respect they greatly surpass the Cossacks of Russia and the Tunguses of the Chinese army, and are the best irregular cavalry that can be imagined. They can hang on the sides of their horses while at speed, directing them by voice and rein, and sheltering themselves in this way from the lances, balls, or shots of their adversaries. At a distance a troop of such horsemen advancing irregularly may be taken for loose horses, of which so many are seen wandering on the plains. They can even cling quite beneath the belly for a short time, still urging and directing their horses. In the war by which Venezuela obtained its independence their services were of great use to the patriotic armies.

Their constant exposure to the open air and prevalent heat has hardened their bodies to an extraordinary degree.

It is remarkable that these llanieros can travel, in a slight dress, over the Andes to the towns of New Grenada, and expose themselves to the rigorous climate of the paramos, or mountain-plains, generally without serious consequences to their health; whilst the inhabitants of the mountains consider a stay in the plains as a certain source of fatal diseases. Though living not far from one another, the inhabitants of these two regions do not frequently visit on account of the antipathy existing between them. When they meet, quarrels are almost inevitable, and the llanieros use the superiority in strength and activity derived from their manner of life with ferocity and cruelty. They are much feared therefore by their neighbours. Though the inhabitants of these plains have lost many of the qualities by which the character of the Spaniard is distinguished, they have preserved a certain sense of politeness and regard for other persons. This is most conspicuous when they are visited by travellers. However great their desire may be to obtain information from their guests, they forbear annoying them by questions until they have satisfied their appetites.

THE END.

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